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# **INTERNATIONAL LIBRARY OF TECHNOLOGY**

**A SERIES OF TEXTBOOKS FOR PERSONS ENGAGED IN THE ENGINEERING  
PROFESSIONS AND TRADES OR FOR THOSE WHO DESIRE  
INFORMATION CONCERNING THEM. FULLY ILLUSTRATED  
AND CONTAINING NUMEROUS PRACTICAL  
EXAMPLES AND THEIR SOLUTIONS**

**PACKING-HOUSE INDUSTRIES  
MANUFACTURE OF LEATHER  
MANUFACTURE OF SOAP**

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INTERNATIONAL TEXTBOOK COMPANY**

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## PREFACE

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The International Library of Technology is the outgrowth of a large and increasing demand that has arisen for the Reference Libraries of the International Correspondence Schools on the part of those who are not students of the Schools. As the volumes composing this Library are all printed from the same plates used in printing the Reference Libraries above mentioned, a few words are necessary regarding the scope and purpose of the instruction imparted to the students of—and the class of students taught by—these Schools, in order to afford a clear understanding of their salient and unique features.

The only requirement for admission to any of the courses offered by the International Correspondence Schools, is that the applicant shall be able to read the English language and to write it sufficiently well to make his written answers to the questions asked him intelligible. Each course is complete in itself, and no textbooks are required other than those prepared by the Schools for the particular course selected. The students themselves are from every class, trade, and profession and from every country; they are, almost without exception, busily engaged in some vocation, and can spare but little time for study, and that usually outside of their regular working hours. The information desired is such as can be immediately applied in practice, so that the student may be enabled to exchange his present vocation for a more congenial one, or to rise to a higher level in the one he now pursues. Furthermore, he wishes to obtain a good working knowledge of the subjects treated in the shortest time and in the most direct manner possible.

In meeting these requirements, we have produced a set of books that in many respects, and particularly in the general plan followed, are absolutely unique. In the majority of subjects treated the knowledge of mathematics required is limited to the simplest principles of arithmetic and mensuration, and in no case is any greater knowledge of mathematics needed than the simplest elementary principles of algebra, geometry, and trigonometry, with a thorough, practical acquaintance with the use of the logarithmic table. To effect this result, derivations of rules and formulas are omitted, but thorough and complete instructions are given regarding how, when, and under what circumstances any particular rule, formula, or process should be applied; and whenever possible one or more examples, such as would be likely to arise in actual practice—together with their solutions—are given to illustrate and explain its application.

In preparing these textbooks, it has been our constant endeavor to view the matter from the student's standpoint, and to try and anticipate everything that would cause him trouble. The utmost pains have been taken to avoid and correct any and all ambiguous expressions—both those due to faulty rhetoric and those due to insufficiency of statement or explanation. As the best way to make a statement, explanation, or description clear is to give a picture or a diagram in connection with it, illustrations have been used almost without limit. The illustrations have in all cases been adapted to the requirements of the text, and projections and sections or outline, partially shaded, or full-shaded perspectives have been used, according to which will best produce the desired results. Half-tones have been used rather sparingly, except in those cases where the general effect is desired rather than the actual details.

It is obvious that books prepared along the lines mentioned must not only be clear and concise beyond anything heretofore attempted, but they must also possess unequalled value for reference purposes. They not only give the maximum of information in a minimum space, but this information is so ingeniously arranged and correlated, and the

## PREFACE



indexes are so full and complete, that it can at once be made available to the reader. The numerous examples and explanatory remarks, together with the absence of long demonstrations and abstruse mathematical calculations, are of great assistance in helping one select the proper formula, method, or process and in teaching him how and when it should be used.

Four of the volumes of this library are devoted to subjects pertaining to Applied Chemistry. The present volume contains treatises on packing-house industries, the manufacture of leather, and the manufacture of soap. All these subjects have been treated very fully, and care has been taken to represent the best modern practice. We believe that there are no other books that treat of the immense packing-house industries; that is, of the utilization of those animal products which cannot be used in the form of meats. The leather and soap industries are so closely related to the packing-house industries that their place in this volume will be fully justified. Both subjects will impart valuable information to the practical tanner and soap maker. It has been the endeavor to expound the dominant principles that govern these industries, and give at the same time a detailed account of the various processes, with special consideration of the most modern American practice.

The method of numbering the pages, cuts, articles, etc. is such that each subject or part, when the subject is divided into two or more parts, is complete in itself; hence, in order to make the index intelligible, it was necessary to give each subject or part a number. This number is placed at the top of each page, on the headline, opposite the page number; and to distinguish it from the page number it is preceded by the printer's section mark (§). Consequently, a reference such as §16, page 26, will be readily found by looking along the inside edges of the headlines until §16 is found, and then through §16 until page 26 is found.

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# PACKING-HOUSE INDUSTRIES

(PART 1)

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## INTRODUCTION

**1. Historical.**—The packing industry is said to have been carried on in the New England States as early as 1640, but not in the way the modern business is conducted. The oldest record of such an establishment, perpetuated to this day, is claimed by a Philadelphia firm, which started packing in the primitive way of the times in 1760 and developed its methods into those of the modern packing house.

The packing industry, with its diversified components as now understood, dates from the year 1818, when an establishment was started in Cincinnati, which city soon became the center of this industry. One reason for this was the surrounding corn-raising area—the natural territory for a steady supply of hogs. As the population and facilities for shipping increased, the corn-belt area moved farther west, followed by the packing houses locating near their supply of raw material. Chicago, being situated in the corn-raising area and having natural transportation facilities because of its location at the head of Lake Michigan, followed Cincinnati as the center of the packing industry, and is now indisputably and universally acknowledged as the center of the meat industries of the world. Thousands of cars of cattle and hogs, both live and dressed, are shipped from Chicago annually in addition to those animals slaughtered for consumption in the immediate vicinity.

Within the last few years, large and important interests have developed in the packing industry still farther west,

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notably in St. Louis, Omaha, St. Joseph, and Kansas City, for the obvious reason of the close proximity of supplies of cattle and hogs raised in the sparsely settled Western States. Although these cities are large packing centers, Chicago, mainly owing to its prestige and almost unequaled water and rail shipping facilities, still maintains its supremacy.

Still more recently the packing industry has spread farther to the southwest, extending even into Texas, after the line of modern tendencies in business, to establish the manufactory at the base of supply of the raw material—in this industry, the live animals for slaughter.

2. The primitive methods of this business have practically been revolutionized. In former times, natural temperatures and ice were the only means available for preserving the manufactured products, in consequence of which the packing was carried on in the winter months only. Today, artificial refrigeration and the power to control temperatures at will have made it possible for this industry to be carried on daily throughout the year. In addition to this, it is now possible to consume the meat of animals slaughtered thousands of miles away from the great consuming centers, it being transported in scientifically built refrigerator cars, a thing unknown until a few years ago.

In addition to artificial refrigeration, another most potent factor in developing the modern, scientific packing industry is applied chemistry. Were it not for the ingenuity of the chemist in finding a way to utilize the offal of slaughtered animals, the price of meat would necessarily be very high. The chemist has turned into practical channels of income what was in former times not only waste, but a source of expense for its removal.

The object of the primitive packing industry was simply to produce meat. The object of the present scientific packing industry is not only to produce meat, but also to utilize every available part of the animal, which objective point is attained to the highest degree in the large modern packing house of today.

**3. Breadth of the Packing Industry.**—The packing industry is so very broad that today it covers an enormous field. Not only does the modern packing house pack pork and beef similarly to when this industry was started on a large scale, but it also produces and handles many foods other than those produced from live stock.

The modern packing establishment may be termed, in common language, a *food factory*. Animal and vegetable foods and compounds of the two are produced in many forms; together with these there are also produced other edible compounds, which closely verge on the pharmaceutical field. This is evidenced by the production of beef extract, which may hardly be considered a food, but rather a stimulant, as prepared in the packing house.

A step further than this are the preparations known as *digestive ferments*, not food, but still alimentary products. Still further bordering on the pharmaceutical field are the preparations frequently produced (in the largest establishments), such as *inspissated ox gall* and the so-called animal extracts, as *cardine*, *testine*, *cerebine*, etc.

**4.** There are so many offshoots in the packing industry today that it is difficult, in fact, to draw a line where this industry ends. So many by-products of the animals slaughtered are now manipulated into finished products by the packers that the whole tendency is to handle in one establishment the entire product and by-product of the slaughtered animals.

When the slaughtering business first became established on a large scale, there grew up in the vicinity of the packing plants independent establishments, the purpose of which was to handle the by-products collected from the packing houses. Glue works, fertilizer works, soap factories, oil and tallow works, and the like were in a large measure separate from the slaughtering concerns. As the packing business developed on modern and scientific lines and became concentrated in the hands of the larger companies, the allied industries were gradually—but, finally, almost completely—taken over



by them. Various important economies were thus effected by unification and are being further effected from time to time.

At the present day, the leading and largest packers carry the elaboration of almost every possible by-product to an advanced stage. Frequently, the elaboration is carried out to the finished article of the product or by-product, so that it goes direct from the packer to the consumer, as evinced by the manufacture among other things of sand-paper, glue, sizing, hair felt, curled hair, anhydrous ammonia, finished fertilizer, soap, pepsin, etc. Still, no matter how the various packing houses may differ in the degree to which finished products are made from their material, they are all actuated by one principle—none permit anything of value to be wasted.

5. The meat-canning industry is closely associated and nearly always contiguous to the packing house, both for convenience and for profit. This industry is complete in itself, although it is practically inseparable from the packing-house industry proper. The canning industry will therefore be described, as the economical management of the modern packing house depends to a very large extent on this resourceful branch of the business.

The most important feature in the utilization of by-products in the packing house is observed in the fertilizer department, as here all animal products not useful for food or manufacturing purposes are converted into a remunerative article—fertilizer—either finished, that is, complete fertilizer, or the crude form, known as *tankage*. This subject will be treated in its proper place. The establishing of this department may be said to mark the transition of the simple slaughter house of former days to the modern packing house in all its phases. Formerly, dressed meat only was produced, and the offal was a source of expense and encumbrance to the packer, who willingly paid for having it taken away. With the knowledge acquired from the utilization of one by-product, the utilization of all followed as a natural consequence.

The establishing of the glue department by the packing houses as a necessary adjunct is among the comparatively recent innovations and at the same time one of the most important. This subject will be treated at length under its proper caption, as will also various other closely associated industries.

**6.** The development of the packing industry as it now exists is due in no small measure to the knowledge and research of the packing-house chemist. Not only has the chemist aided this development, but even today he is engaged in furthering the utilization of the various waste products. In addition to this, the modern packer depends on chemistry to aid him in conducting the whole industry on an economical and profitable basis.

This will be readily apparent when the many operations are described in which chemistry plays such an important part in determining the grade or class and, consequently, the price of the finished product. The chemist of the packing house is daily called on to perform tests and analyses by which each day's output is controlled. For example, the amount of tallow or grease remaining in the cooked offal is such an important item that a daily report on the percentage left in this material is given to the superintendent. This one feature alone may be the cause of profit or an immense loss to the establishment, and thus shows the importance of applied chemistry in this industry.

The field for the chemist in the development of by-products is most inviting, offering unlimited opportunity for the research and development of industrial and other uses for the once despised offal.

**7. Method of Conducting Establishments.**—The modern, large packing house is conducted on strictly business principles in every department. The different departments are regarded as independent concerns, the raw material received by each department being considered as purchased from an independent source, and the cost price

charged up to its account. At the same time the department furnishing the material is credited with the price charged. The finished product turned out by each separate department, when sold, has the amount received credited to that department. All supplies, labor, utensils, etc. constitute a direct charge to the department receiving them; and, in addition, to each is apportioned, pro rata, insurance, taxes, cartage, steam, light, office, selling expenses, etc. In this way it is ascertained what each department is contributing to the general profit or loss. Each day a report of its receipts, shipments, labor, etc. is given to the general manager, who, in the summary, is thus enabled at a glance to see the status and condition of the whole establishment. The labor cost is closely scrutinized, and should it be found that this is in excess of the regulation established, an investigation immediately results and an explanation is obtained. From years of experience and by frequent tests made in all departments of the establishment, the exact cost of each product and by-product is accurately known and regulated.

Constant investigations, with a view to perfecting methods and curtailing wastes, are being made, and in this way new avenues are found for the still further profitable working and disposition of by-products.

8. In no business is there more attention given to detail, and probably there is no business where the average profit on each individual product is of such slight margin that the slightest inattention to any detail results in such serious losses. There have been periods in the packing industry when operations have been carried on in almost every department at a positive loss; but as so much machinery and apparatus are required in this industry, the loss incurred from operating at a small loss was far less than would have resulted from idle machinery, rusty tanks, etc. It may be truthfully said that of all departments of this industry there is only one from which a good profit is always expected and almost always obtained, namely, the sausage department. This branch of the industry has the

advantage of being able to utilize parts from all slaughtered animals passing the necessary inspection, while the other departments manufacturing the goods are restricted to a particular class of material.

The general methods of treating and caring for packing-house products and by-products will be presented as they are daily carried out in the modern packing houses in the United States. If it were not for the utilization of by-products, dressed beef would have to be sold at a much higher price. The value of beef from the average steer, broadly speaking, is about three-fourths of the total value of the products obtained from the animal.

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## MEAT INSPECTION

9. In 1906, owing to various loose and negligent methods and practices in many packing houses, a most rigid government inspection law, covering the whole packing and slaughtering industry, was passed by Congress, going into effect on October 1. This law was enacted for the purpose of preventing the use in interstate or foreign commerce of meat and meat-food products that are unsound, unhealthful, unwholesome, or otherwise unfit for human food, under the authority conferred on the Secretary of Agriculture by the provisions of the act of Congress approved June 30, 1906.

Regulations are prescribed for the inspection, reinspection, examination, supervision, disposition, and method and manner of handling of live cattle, sheep, swine, and goats, and the carcasses and meat-food products of cattle, sheep, swine and goats, and for the sanitation of the establishments at which inspection is maintained. These regulations supersede those previously in force, namely, the regulations of 1897 and those of 1904, except the portions of the latter law and amendments that relate to the microscopic inspection of pork.

As the recent law made necessary extreme and radical changes in many of the products, their nomenclature, and methods of preparation, and as this law has such a direct

bearing and importance on the whole industry, it is given here in full, for guidance and reference.

A national pure-food law was also enacted in 1906. This law likewise has a direct bearing on many of the products emanating from the packing house, especially as relating to the names under which the prepared food products are sold.

The new meat-inspection law and the national pure-food law, the latter known as The Food and Drugs Act, are correlated in many respects as applied to food products made in the packing house; hence the rulings and interpretations of the law as applied to these products are also given.

While the use of preservatives in food products for domestic consumption is prohibited, the law permits the use, under certain restrictions, of preservatives in meat and meat-food products for export, but does not permit the use of any dye or coloring matter not permitted in meats prepared for interstate trade.

## **REGULATIONS GOVERNING THE MEAT INSPECTION OF THE UNITED STATES DEPARTMENT OF AGRICULTURE**

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(NOT INCLUDING REGULATIONS FOR MICROSCOPIC INSPECTION OF PORK OR REGULATIONS AFFECTING TRANSPORTATION OF MEAT IN INTERSTATE OR FOREIGN TRADE)

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*Issued under authority conferred on the Secretary of Agriculture  
by the act of Congress approved June 30, 1906*

[B. A. I. ORDER No. 137]

## **REGULATIONS GOVERNING THE MEAT INSPECTION OF THE UNITED STATES DEPARTMENT OF AGRICULTURE**

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### **GENERAL REGULATIONS**

#### **SCOPE OF INSPECTION**

**REGULATION 1.**—All slaughtering, packing, meat-canning, salting, rendering, or similar establishments whose meats or meat food products, in whole or in part, enter into interstate or foreign commerce shall have inspection under these regulations unless exempted from inspection by the Secretary of Agriculture. Only farmers, and retail butchers or retail dealers supplying their customers, may be exempted under the law, but they are, nevertheless, subject to the provision of the law which places a penalty upon any person who shall sell or offer for sale or transportation, for interstate or foreign commerce, any meat or meat food products which are diseased, unsound, unhealthful, unwholesome, or otherwise unfit for human food, knowing that such meat food products are intended for human consumption.

All carcasses and parts of carcasses of cattle, sheep, swine, and goats, and all meats and meat food products thereof entering into interstate or foreign commerce shall show either that they have been inspected and passed or that they have been exempted from inspection under these regulations. All meats and meat food products on hand

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October 1, 1906, at establishments where inspection has not been previously maintained, or which have been inspected under previously existing law and regulations, shall be examined and labeled under these regulations before being allowed to enter into interstate or foreign commerce.

#### **APPLICATION FOR INSPECTION OR EXEMPTION**

**REGULATION 2.**—The proprietor or operator of each slaughtering, packing, meat-canning, rendering, or similar establishment engaged in the slaughtering of cattle, sheep, swine, or goats, or in the packing, canning, or other preparation of any food product into which the meats or meat food products of said animals enter in whole or in part, for interstate or foreign commerce, shall make application to the Secretary of Agriculture for inspection or for exemption from inspection. The said application shall be made in writing, addressed to the Secretary of Agriculture, Washington, D. C., and shall state the location of the establishment, the address of the owner or of a duly authorized officer or agent of the same, the kinds of animals slaughtered, the estimated number of animals of any species slaughtered per day and per week, or the estimated amount of meats or meat food products received from other establishments, and the character, quantity, and proposed disposition of the products of said establishment. Blank application forms will be furnished by the Chief of the Bureau of Animal Industry upon request. If an establishment is not in a sanitary condition, inspection shall not be established.

#### **EXEMPTION FROM INSPECTION**

(a) If, in the judgment of the Secretary of Agriculture, the retail butcher or retail dealer who is engaged in supplying his customers through the medium of interstate or foreign commerce should be exempted from Federal inspection, a certificate of exemption will be furnished to the applicant for use with transportation companies and other companies and persons in securing the movement of his products.

#### **OFFICIAL NUMBER**

**REGULATION 3.**—If inspection is established under said application the Secretary of Agriculture will give said establishment a number by which all its meats and meat food products shall thereafter be known, and this number shall be used by the inspectors of the Department of Agriculture, and also by the proprietors of said establishment, to mark the meats and meat food products of the establishment as hereinafter prescribed. Establishments having one or more branches may use the same number for all by affixing a serial letter in connection with the number to differentiate the products of the different branches. Each establishment at which inspection is maintained must be separate

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and apart from any other establishment engaged in similar business at which inspection is not maintained.

(a) Retail butchers and dealers who have been exempted from inspection under these regulations will be given numbers by which their products will be known.

#### **DESIGNATION OF INSPECTORS**

**REGULATION 4.**—The Secretary of Agriculture will designate an inspector to take charge of the inspection at each establishment where inspection is maintained, and will detail to said inspector such assistants as may be necessary to carry on properly the work of inspection and supervision at said establishment. For the purpose of enforcing the law and regulations the inspector and all employes under his direction shall have access at all times, by day or night, whether the establishment be operated or not, to every part of said establishment.

#### **OFFICE ROOM**

**REGULATION 5.**—Office room, including light and heat, shall be provided by proprietors of establishments, rent free, for the exclusive use of the inspector and other employes of the Department on duty at each establishment. The room or rooms set apart for this purpose must be properly ventilated, conveniently located, and provided with lockers suitable for the protection and storage of such supplies as may be required; all to meet the approval of the inspector in charge.

#### **ALL CARCASSES AND PRODUCTS INSPECTED**

**REGULATION 6.**—All cattle, sheep, swine, or goats slaughtered at an establishment at which inspection is maintained, and all meats and meat food products prepared therein shall be inspected, handled, and prepared as required by these regulations.

#### **NOTICE OF DAILY OPERATIONS**

**REGULATION 7.**—The manager of each establishment at which inspection is maintained shall inform the inspector in charge, or his assistant, when work has been concluded for the day, and of the day and hour when work will be resumed. Under no circumstances shall an establishment be operated except under the supervision of an employe of the Department. All slaughtering must be done within reasonable hours and with reasonable speed, the character of the establishment being considered. Where one inspector is detailed to conduct the work at two or more small establishments where few animals are slaughtered, the inspector in charge may designate the hours for slaughter. No work shall be performed at establishments where inspection is maintained during any day on which such work is prohibited by the law of the State or Territory in which the establishment is located.



**BADGES**

**REGULATION 8.**—Each employe of the Department engaged in inspection under these regulations will be furnished with a numbered badge, which he shall wear over the left breast on the outer clothing while in the performance of his official duties, and which shall not be allowed to leave his possession.

**BRIBERY**

**REGULATION 9.**—It is a felony, punishable by fine and imprisonment, for any person, firm, or corporation, or any agent or employe of any person, firm, or corporation, to give, pay, or offer, directly or indirectly, to any Department employe authorized to perform any duty under these regulations, any money or other thing of value with intent to influence said employe in the discharge of his duty under these regulations. It is also a felony, punishable by fine and imprisonment, for any Department employe engaged in the performance of duty under these regulations to receive or accept from any person, firm, or corporation engaged in interstate or foreign commerce, any gift, money, or other thing of value given with any purpose or intent whatsoever.

**SANITATION**

**REGULATION 10.**—Upon receipt of an application for inspection the Secretary of Agriculture will cause to be made an examination of the premises, and will indicate the requirements for sanitation and the necessary facilities for inspection.

**REGULATION 11.**—In order that the carcasses of cattle, sheep, swine, and goats, and the meats and meat food products thereof, may be admitted to interstate or foreign commerce, it is necessary under the law that the establishments in which the animals are slaughtered, or the meats and meat food products are prepared, cured, packed, stored, or handled, shall be suitably lighted and ventilated and maintained in a sanitary condition. All work in such establishments shall be performed in a cleanly and sanitary manner.

(a) Ceilings, side walls, pillars, partitions, etc., shall be frequently whitewashed or painted, or, where this is impracticable, they shall, when necessary, be washed, scraped, or otherwise rendered sanitary. Where floors or other parts of a building, or tables or other parts of the equipment, are so old or in such condition that they cannot be readily made sanitary, they shall be removed and replaced by suitable materials or otherwise put in a condition acceptable to the inspector in charge. All floors upon which meats are piled during the process of curing shall be so constructed that they can be kept in a clean and sanitary condition, and such meats shall also be kept clean.

(b) All trucks, trays, and other receptacles, all chutes, platforms, racks, tables, etc., and all knives, saws, cleavers, and other tools, and all utensils and machinery used in moving, handling, cutting, chopping, mixing, canning, or other process, shall be thoroughly cleansed daily, if used.

(c) The aprons, smocks, or other outer clothing of employes who handle meat in contact with such clothing shall be of a material that is readily cleansed and made sanitary, and shall be cleansed daily, if used. Employes who handle meats or meat food products shall be required to keep their hands clean.

(d) All toilet rooms, urinals, and dressing rooms shall be entirely separated from compartments in which carcasses are dressed or meats or meat food products are cured, stored, packed, handled, or prepared. They shall be sufficient in number, ample in size, and fitted with modern lavatory accommodations, including toilet paper, soap, running water, towels, etc. They shall be properly lighted, suitably ventilated, and kept in a sanitary condition. Managers of establishments must see that employes keep themselves clean.

(e) The rooms or compartments in which meats or meat food products are prepared, cured, stored, packed, or otherwise handled shall be lighted and ventilated in a manner acceptable to the inspector in charge and shall be so located that odors from toilet rooms, catch-basins, casing departments, tank rooms, hide cellars, etc., do not permeate them. All rooms or compartments shall be provided with cuspidors, which employes who expectorate shall be required to use.

(f) Persons affected with tuberculosis or any other communicable disease shall not be knowingly employed in any of the departments of establishments where carcasses are dressed, meats handled, or meat food products prepared, and any employe suspected of being so affected shall be so reported by the inspector in charge to the manager of the establishment and to the Chief of the Bureau of Animal Industry.

(g) The fattening of hogs or other animals on the refuse of slaughterhouses will not be permitted on the premises of an establishment where inspection is maintained, and no use incompatible with proper sanitation shall be made of any part of the premises on which such establishment is located. All yards, fences, pens, chutes, alleys, etc., belonging to the premises of such establishment shall, whether they are used or not, be maintained in a sanitary condition.

(h) Butchers who dress diseased carcasses shall cleanse their hands of all grease and then immerse them in a prescribed disinfectant and rinse them in clear water before engaging again in dressing or handling healthy carcasses. All butchers' implements used in dressing diseased carcasses shall be cleansed of all grease and then sterilized, either in boiling water or by immersion in a prescribed disinfectant, and rinsed in clear water before being again used in dressing healthy carcasses.

Facilities for such cleansing and disinfection, approved by the inspector in charge, shall be provided by the establishment. Separate trucks, etc., shall be furnished for handling diseased carcasses and parts. Following the slaughter of an animal affected with an infectious disease a stop shall be made until the implements have been cleansed and disinfected unless duplicate implements are provided.

(i) Inspectors are required to furnish their own knives for use in dissecting or incising diseased carcasses or parts, and are required to use the same means for disinfecting knives, hands, etc., that are prescribed for employes of the establishment.

(j) Meats and meat food products intended for rendering into edible products must be prevented from falling on the floor, while being emptied into the tanks, by the use of some device, such as a metal funnel.

(k) Plans of new plants and of plants to be remodeled should be submitted to the Secretary of Agriculture.

(l) Carcasses or parts of carcasses inflated with air blown from the mouth shall not be marked "U. S. Inspected and Passed."

(m) Carcasses dressed with skewers that have been held in the mouth shall not be marked "U. S. Inspected and Passed."

### INTERPRETATION AND DEFINITIONS OF WORDS AND TERMS

REGULATION 12.—Wherever in these regulations the following words, names, or terms are used they shall be construed as follows:

*Inspectors and Department Employes.*—These terms shall mean, respectively, inspectors and employes of the Bureau of Animal Industry.

*"U. S. Inspected and Passed."*—This phrase shall mean that the carcasses, parts of carcasses, meats, and meat food products so marked are sound, healthful, wholesome, and contain no dyes, chemicals, preservatives, or ingredients which render meats or meat food products unsound, unhealthful, unwholesome, unclean, or unfit for human food.

*Rendered into Lard or Tallow.*—This phrase shall mean that the carcasses, parts of carcasses, meats, and meat food products so designated have been passed for the preparation of lard or tallow only.

*"U. S. Inspected and Condemned."*—This phrase shall mean that the carcasses, parts of carcasses, and meat food products so marked are unfit for food and shall be destroyed for food purposes.

*Carcass.*—This word shall mean an animal that has been killed under these regulations, including all parts which are to be used for food.

*Primal Parts of Carcass.*—This phrase shall mean the usual sections or cuts of the dressed carcass commonly known in the trade, such as sides, quarters, shoulders, hams, backs, bellies, etc., and entire edible

organs, such as tongues, livers, etc., before they have been cut, shredded, or otherwise subdivided preliminary to use in the manufacture of meat food products.

*Meat Food Products.*—This term shall mean any product used for food into the composition of which any portion of the carcass enters, or in the preparation of which any portion of the carcass is used, including lard, mince meat, extracts, gelatin, oleomargarine, butterine, soups, etc.

*Vinegar.*—The word vinegar, as used herein, shall mean cider vinegar, wine vinegar, malt vinegar, sugar vinegar, glucose vinegar, or spirit vinegar, as defined by the Committee on Food Standards in Circular No. 10, Secretary's Office, United States Department of Agriculture.

## ANTE-MORTEM EXAMINATION AND INSPECTION

REGULATION 13.—An ante-mortem examination and inspection shall be made of all cattle, sheep, swine, and goats about to be slaughtered before they shall be allowed to enter an establishment at which inspection is maintained. Said examination and inspection shall be made in the pens, alleys, or chutes of the establishment at which the animals are about to be slaughtered. The proprietors of the establishments at which the said ante-mortem inspection is conducted shall provide satisfactory facilities for conducting said inspection and for separating and holding apart from healthy animals those showing symptoms of disease.

All animals showing symptoms or suspected of being affected with any disease or condition which, under these regulations, would probably cause their condemnation when slaughtered, shall be marked by affixing to the ear or tail a metal tag as provided in Regulation 20.

All such animals, except as hereinafter provided, shall be slaughtered separately, either before regular slaughter has commenced or at the close of the regular slaughter, and shall be duly identified by a representative of the establishment to the inspector on duty on the killing floor before the skins are removed or the carcasses opened for evisceration.

Animals which have been tagged for pregnancy and which have not been exposed to any infectious or contagious diseases are not required to be slaughtered, but before any such animal is removed from the establishment the tag shall be detached by a Department employe and returned with his report to the inspector in charge.

(a) If any pathological condition is suspected in which the question of temperature is important, such as Texas fever, anthrax, pneumonia, blackleg, or septicemia, the exact temperature should be taken. Due consideration, however, must be given to the fact that extremely high temperatures may be found in otherwise normal hogs when subjected to exercise or excitement, and a similar condition may obtain to a less

degree among other classes of animals. Animals commonly termed "downers," or crippled animals, shall be tagged, as provided for in Regulation 20, in the abattoir pens for the purpose of identification at the time of slaughter, and shall be passed upon in accordance with these regulations.

### **POST-MORTEM INSPECTION AT TIME OF SLAUGHTER**

**REGULATION 14.**—The inspector or his assistants shall, at the time of slaughter, make a careful inspection of all animals slaughtered. The head, tail, thymus gland, bladder, caul, and the entire viscera, and all parts and blood used in the preparation of meat food products shall be retained in such manner as to preserve their identity until after the post-mortem examination has been completed, in order that they may be identified in case of condemnation of the carcass. Suitable racks or metal receptacles shall be provided for retaining such parts.

Carcasses and parts thereof found to be sound, healthful, wholesome, and fit for human food shall be passed and marked as provided in these regulations.

Should any lesion of disease or other condition that would probably render the meat or any organ unfit for food purposes be found on post-mortem examination, such meat or organ shall be marked immediately with a tag, as provided in Regulation 27. Carcasses which have been so marked shall not be washed or trimmed unless such washing or trimming is authorized by the inspector.

### **DISPOSAL OF DISEASED CARCASSES AND ORGANS**

**REGULATION 15.**—The carcasses or parts of carcasses of all animals which are slaughtered at an establishment where inspection is maintained, and which are found at time of slaughter or at any subsequent inspection to be affected with any of the diseases or conditions named below, shall be disposed of according to the section of this regulation pertaining to the disease or condition. It is to be understood, however, that owing to the fact that it is impracticable to formulate rules covering every case, and to designate at just what stage a process becomes loathsome or a disease noxious, the decision as to the disposition of all carcasses, parts, or organs not specifically covered by these regulations shall be left to the veterinary inspector in charge. Carcasses found, before evisceration has taken place, to be affected with an infectious or contagious disease, including tuberculosis, shall not be eviscerated at the regular killing bed or bench, but shall be taken to the retaining room, or other specially prepared place, separate from other carcasses, and there opened and examined.

(a) *Anthrax, or Charbon*.—All carcasses showing lesions of this disease, regardless of the extent of the disease, shall be condemned and immediately tanked, including the hide, hoofs, horns, viscera, fat, blood, and all other portions of the animal. The killing bed upon which the animal was slaughtered shall be disinfected with a 10 per cent. solution of formalin, and all knives, saws, cleavers, and other instruments which have come in contact with the carcass shall be treated as provided in Regulation 11, paragraph (h), before being used upon another carcass.

(b) *Blackleg*.—Carcasses of animals showing lesions of blackleg shall be condemned.

(c) *Hemorrhagic Septicemia*.—Carcasses of animals affected with this disease shall be condemned.

(d) *Pyemia and Septicemia*.—Carcasses showing lesions of either of these diseases shall be condemned.

(e) *Rabies*.—Carcasses of animals which showed symptoms of rabies before slaughter shall be condemned.

(f) *Tetanus*.—Carcasses of animals which showed symptoms of tetanus before slaughter shall be condemned.

(g) *Malignant Epizootic Catarrh*.—Carcasses of animals affected with this disease and showing generalized inflammation of the mucous membranes shall be condemned.

(h) *Hog Cholera and Swine Plague*.—(1) Carcasses showing well-marked and progressive lesions of hog cholera or swine plague in more than two of the organs (skin, kidneys, bones, or lymphatic glands) shall be condemned.

(2) Carcasses showing slight lesions which are confined to the kidneys and lymphatic glands may be passed.

(3) Carcasses which reveal lesions more numerous than those described for carcasses to be passed, but not so severe as the lesions described for carcasses to be condemned, may be rendered into lard, provided they are cooked by steam for four hours at a temperature not lower than 220° F.

(4) In inspecting carcasses showing lesions of the skin, bones, kidneys, or lymphatic glands, due consideration shall be given to the extent and severity of the lesions found in the viscera.

(i) *Actinomycosis, or Lumpy Jaw*.—(1) If the carcass is in a well-nourished condition and there is no evidence upon post-mortem examination that the disease has extended from a primary area of infection in the head, the carcass may be passed, but the head, including the tongue, shall be condemned.

(2) If the carcass is in a well-nourished condition and the disease has extended beyond the primary area of infection, the disposition shall be made in accordance with the regulations relating to tuberculosis.

(j) *Caseous Lymphadenitis*.—When the lesions are limited to the superficial lymphatic glands or to a few nodules in an organ, involv-

ing also the adjacent lymphatic glands, and the carcass is well nourished, the meat may be passed after the affected parts are removed and condemned. If extensive lesions, with or without pleuritic adhesions, are found in the lungs, or if several of the visceral organs contain caseous nodules and the carcass is emaciated, it shall be condemned.

(*k*) *Tuberculosis*.—All carcasses affected with tuberculosis and showing emaciation shall be condemned. All other carcasses affected with tuberculosis shall be condemned, except those in which the lesions are slight, calcified, or encapsulated, and are confined to the tissues indicated in any one of the following five paragraphs, or to a less number of such tissues, and excepting also those which may, under paragraphs (6) and (7) below, be rendered into lard or tallow.

(1) The cervical lymphatic glands and two groups of visceral lymphatic glands in a single body cavity, such as the cervical, bronchial, and mediastinal glands, or the cervical, hepatic, and mesenteric glands.

(2) The cervical lymphatic glands and one group of visceral lymphatic glands and one organ in a single body cavity, such as the cervical and bronchial glands and the lungs, or the cervical and hepatic glands and the liver.

(3) Two groups of visceral lymphatic glands and one organ in a single body cavity, such as the bronchial and mediastinal glands and the lungs, or the hepatic and mesenteric glands and the liver.

(4) The cervical lymphatic glands and one group of visceral lymphatic glands in each body cavity, such as the cervical, bronchial, and hepatic glands.

(5) Two groups of visceral lymphatic glands in the thoracic cavity and one group in the abdominal cavity, or one group of visceral lymphatic glands in the thoracic cavity and two groups in the abdominal cavity, such as the bronchial, mediastinal, and hepatic glands, or the bronchial, hepatic, and mesenteric glands.

(6) Carcasses affected with tuberculosis, in which the lesions of the disease are located as described in any one of the preceding five paragraphs, but are slight and in a state of caseation, or liquefaction necrosis, or surrounded by hyperemic zones, and also those in which slight, calcified, or encapsulated lesions are found in more visceral organs or more groups of visceral lymphatic glands than are specified in any one of the preceding five paragraphs, may be rendered into lard or tallow after the diseased parts are removed. The carcasses shall be cooked by steam at a temperature not lower than 220° F. for not less than four hours.

(7) Carcasses in which the cervical lymphatic glands, one organ, and the serous membrane in a single body cavity, such as the cervical lymphatic glands, the lungs, and the pleura, or the cervical lymphatic glands, the liver, and the peritoneum, are affected with tuberculosis



may be rendered into lard or tallow after the diseased parts are removed. The carcasses shall be cooked by steam at a temperature not lower than 220° F. for not less than four hours.

(8) All condemned carcasses, parts of carcasses, or organs showing lesions of tuberculosis shall be deposited in receptacles provided for that purpose, and shall either be tanked at once or be locked in the "condemned" room until such time as an employe of the Department can see that they are placed in the tank.

(9) All heads and other parts showing lesions of tuberculosis shall be condemned.

(l) *Texas Fever*.—Carcasses showing sufficient lesions to warrant the diagnosis of Texas fever shall be condemned.

(m) *Parasitic Ictero-Hematuria*.—Carcasses of sheep affected with this disease shall be condemned.

(n) *Mange, or Scab*.—Carcasses of animals affected with mange, or scab, in advanced stages, shall be condemned. When the disease is slight the carcass may be passed.

(o) *Tapeworm Cysts*.—Carcasses of animals slightly affected with tapeworm cysts may be rendered into lard or tallow, but extensively affected carcasses shall be condemned.

(p) *Pneumonia, Pleurisy, Enteritis, Peritonitis, and Metritis*.—Carcasses showing generalized inflammation of one of the following tissues—the lungs, pleuræ, intestines, peritoneum, or the uterus—whether in acute or chronic form, shall be condemned.

(q) *Icterus*.—Carcasses showing an intense yellow or greenish-yellow discoloration after proper cooling shall be condemned. Carcasses which exhibit a yellowish tint directly after slaughter, but lose this discoloration on chilling, may be passed for food.

(r) *Uremia and Sexual Odor*.—Carcasses which give off the odor of urine or a strong sexual odor shall be condemned.

(s) *Urticaria, Etc.*—Hogs affected with urticaria (diamond skin disease) *Tinea, tonsurans, Demodex folliculorum*, or erythema may be passed after detaching and condemning the skin, if the carcass is otherwise fit for food.

(t) *Melanosis, Etc.*—Carcasses of animals showing any disease or injury, such as traumatic pericarditis, generalized melanosis, pseudo-leukemia, etc., which causes considerable elevation of temperature or affects the system of the animal, shall be condemned.

(u) *Bruises, Abscesses, Liver Flukes, Etc.*—Any organ or part of a carcass which is badly bruised or which is affected by malignant tumors, abscesses, suppurating sores, or liver flukes shall be condemned, but when the lesions are so extensive as to affect the whole carcass, the whole carcass shall be condemned.

(v) *Emaciation and Anemia*.—Carcasses of animals too emaciated or anemic to produce wholesome meat and those carcasses which show



a slimy degeneration of the fat or a serious infiltration of the muscles shall be condemned.

(w) *Pregnancy and Parturition*.—Carcasses of animals in advanced stages of pregnancy (showing signs of preparation for parturition), also carcasses of animals which have within ten days given birth to young and in which there is no evidence of septic infection, may be rendered into lard or tallow if desired by the manager of the establishment, otherwise they shall be condemned.

(x) *Immaturity*.—Carcasses of animals too immature to produce wholesome meat, all unborn and stillborn animals, also carcasses of calves, pigs, kids, and lambs under three weeks of age shall be condemned.

(y) *Diseased Parts*.—In all cases where carcasses showing localized lesions of disease are passed or rendered into lard or tallow, the diseased parts must be removed before the "U. S. Retained" tag is taken from the carcass, and such parts shall be condemned.

(z) *Careless Scalding*.—Hogs which have been allowed to pass into the scalding vat alive shall be condemned.

(aa) *Dead Animals*.—All animals that die in abattoir pens, and those in a dying condition before slaughter, shall be tagged as provided in Regulation 21, and in all cases shall be condemned. In conveying animals which have died in the pens of the establishment to the tank they shall not be allowed to pass through compartments in which food products are prepared. No dead animals shall be brought into an establishment for rendering from outside the premises of said establishment.

#### **"RETAINING" AND "CONDEMNED" ROOMS**

REGULATION 16.—Separate compartments, to be known as "retaining rooms," or other special places for final inspection, shall be set apart at all establishments at which inspection is maintained, and all carcasses and parts marked with a "U. S. Retained" tag shall be held in these rooms pending final inspection. These rooms shall be rat proof and furnished with abundant light; the floors shall be of cement, metal, or brick laid in cement. They shall be provided with facilities for locking, and locks for this purpose will be furnished by the Department. The keys to such locks shall remain in the custody of the inspector or his assistant.

Immediately after the final inspection of carcasses and parts marked with "U. S. Retained" tags is completed, those found to be wholesome and fit for human food shall be released by the veterinary inspector conducting the inspection, who shall remove the "U. S. Retained" tags, and the carcasses shall be removed from the retaining rooms and marked "U. S. Inspected and Passed," as provided in Regulation 28.

The floors and walls of all retaining rooms shall be washed with hot water and disinfected after diseased animals are removed, and before any "retained" animals are again placed therein.

Carcasses or parts of carcasses found on final inspection to be unsound, unhealthful, unwholesome, or otherwise unfit for human food shall be marked "U. S. Inspected and Condemned," as provided in Regulation 28, and shall be removed from the retaining room to the "condemned" room, if not tanked within twenty-four hours.

(a) In each establishment at which condemned carcasses or meat food products are held for more than twenty-four hours after condemnation, there shall be provided a room entirely separate from all other rooms in the establishment. This room shall be secure and shall be provided with a lock, the key of which shall remain in the custody of a Department employe. This room shall be known as the "condemned room," and shall be kept locked at all times except when condemned meat or meat food product is being taken into or from the said room under the supervision of a Department employe.

All condemned carcasses shall be removed from retaining rooms within twenty-four hours after they are condemned, except in questionable cases, when they are held pending a decision of the inspector in charge. Condemned carcasses shall not be allowed to accumulate, but shall be removed from the "condemned" rooms, treated with coloring substances, or otherwise treated, as provided in Regulation 18, paragraph (b), and tanked within a reasonable time after condemnation. Carcasses of diseased animals which are eviscerated in the retaining room or in the specially prepared place under the provisions of Regulation 15, shall, unless passed, be removed immediately either to the "condemned" room or to the tank.

REGULATION 17.—*Bruised Parts*.—When a portion of a carcass is to be condemned on account of slight bruises, which cannot be properly removed until the carcass is chilled, the carcass shall be marked with a "U. S. Retained" tag and placed in the retaining room. After chilling, the affected portion shall be cut out, marked "U. S. Inspected and Condemned," and removed to the tank or locked in the "condemned" room, and the remainder of the carcass shall be marked "U. S. Inspected and Passed."

#### TANKS AND TANKING

REGULATION 18.—All condemned carcasses, parts of carcasses, and meat food products shall be tanked as follows:

(a) After the lower opening of the tank has been securely sealed by an employe of the Department, and the condemned carcasses, parts, and meat food products are placed therein in his presence, the upper opening shall be likewise securely sealed by such employe, whose duty it shall be then to see that a sufficient force of steam is turned into the tank and maintained a sufficient length of time effectually to

render the contents unfit for any edible product. Tanks for this purpose shall be so located or operated that the fumes and odors therefrom shall not pervade compartments in which carcasses are dressed or edible products prepared. Wire and lead seals are provided by the Department for sealing tanks.

(b) A sufficient quantity of coloring matter or other substance to be designated by the Department shall be used in connection with the tanking of all condemned carcasses, parts of carcasses, meats, and meat food products, to destroy them effectually for food purposes.

(c) The seals of tanks containing condemned meats or the tankage thereof shall be broken only by an employe of the Department.

(d) If an establishment where inspection is maintained fails to permit the treatment and tanking of condemned carcasses, parts of carcasses, meats, or meat food products, as required by these regulations, the inspector in charge shall report that fact to the Department, in order that inspection may be withdrawn from such establishment.

REGULATION 19.—Any meats or meat food products condemned at establishments which have no facilities for tanking shall be treated as provided in Regulation 18, paragraph (b), and removed to an establishment indicated by the inspector in charge and there tanked and rendered under the supervision of an employe of the Department.

### **LABELS, TAGS, AND BRANDS**

#### **"U. S. SUSPECT" TAG**

REGULATION 20.—To the ear or tail of each animal inspected under Regulation 13 which shows symptoms or is suspected of being affected with any disease or condition which, under these regulations, may cause its condemnation on post-mortem inspection, there shall be affixed by a Department employe at the time of inspection a numbered metal tag bearing the words "U. S. Suspect." The employe who affixes the tag shall report the number to the inspector in charge. This "U. S. Suspect" tag shall remain upon the animal until the preliminary post-mortem inspection at the time of slaughter. If no lesions of disease are then discovered the "U. S. Suspect" tag shall be removed and forwarded to the inspector in charge, with a report that the carcass has been inspected and passed, and the carcass shall be labeled or stamped "U. S. Inspected and Passed," as hereinafter provided.

#### **ANTE-MORTEM CONDEMNED TAG**

REGULATION 21.—To the ear of each animal which is found in a dying condition or dead on the premises of an establishment at which inspection is maintained there shall be affixed by a Department employe a numbered metal tag bearing the words "U. S. Condemned." The ear bearing the tag shall not be removed from the carcass. The number of this tag shall be reported to the inspector in charge by the employe

who affixes it. This tag shall remain on the condemned carcass until it reaches the tank, and immediatly before tanking it shall be removed by the Department employe who is supervising the tanking and returned with a report to the inspector in charge.

#### **LABELING BEEF FOR EXPORT**

**REGULATION 22.**—Upon each quarter of each dressed beef carcass inspected and passed for export there shall be placed by a Department employe a meat-inspection label or mark, which shall bear the number of the establishment and the words "U. S. Inspected and Passed."

#### **LABELING BEEF FOR INTERSTATE COMMERCE**

**REGULATION 23.**—Upon each dressed beef carcass inspected and passed for interstate commerce there shall be placed by a Department employe at the time of inspection at least ten labels or marks bearing the number of the establishment and the words "U. S. Inspected and Passed."

#### **LABELING CANNERS**

**REGULATION 24.**—Upon each quarter of each dressed beef carcass inspected and passed, and which is to be cut up and prepared in the establishment in which the animal was slaughtered, or in another establishment where inspection is maintained, there shall be placed by a Department employe at the time of inspection one label or mark bearing the establishment number and the words "U. S. Inspected and Passed." If, however, a primal part of any such carcass is to leave the establishment for interstate or foreign commerce, such primal part, or the container thereof, must be labeled, stamped, or branded, under the personal supervision of a Department employe, with the establishment number and the words "U. S. Inspected and Passed."

#### **LABELING CARCASSES OF SHEEP, CALVES, SWINE, AND GOATS**

**REGULATION 25.**—Upon the dressed carcasses of sheep, calves, swine, and goats inspected and passed for interstate or export commerce there shall be placed by a Department employe at the time of inspection at least two labels or marks bearing the number of the establishment and the words "U. S. Inspected and Passed."

#### **STAMP ON CLOTH WRAPPING**

**REGULATION 26.**—When the dressed carcasses or parts thereof of cattle, sheep, calves, swine, or goats are wrapped or inclosed for shipment for interstate or export commerce in burlap, muslin, cheese cloth, or other similar substance, the covering shall bear a meat-inspection stamp or other mark on which shall appear the establishment number and the words "U. S. Inspected and Passed."

**"U. S. RETAINED" TAG**

REGULATION 27.—Upon each carcass, or part or detached organ thereof, inspected under Regulation 14, in which any lesion of disease or other condition is found that would probably render the meat or any organ unfit for food purposes, there shall be placed by a Department employe at the time of inspection a paper tag, numbered in duplicate, bearing the words "U. S. Retained," attached by a wire and seal. The inspector who attaches this "U. S. Retained" tag shall detach the numbered stub thereof and return it with his report to the inspector in charge. The other portion shall accompany the carcass to the retaining room.

**"U. S. CONDEMNED" STAMP**

REGULATION 28.—Upon each carcass, or part or detached organ thereof, which is found on final inspection in the retaining room, or other special place for final inspection, to be unsound, unhealthful, unwholesome, or otherwise unfit for human food, there shall be stamped conspicuously by a Department employe at the time of inspection the words "U. S. Inspected and Condemned." In addition the "U. S. Retained" tag shall remain upon the carcass and shall be stamped with the words "U. S. Inspected and Condemned." This stamped "U. S. Retained" tag shall accompany the carcass to the tank and shall be removed immediately before tanking by the Department employe who is supervising that operation, and he shall write or stamp upon the tag the word "Tanked," the date, sign his name, and return the tag with his report to the inspector in charge. If, however, upon final inspection the carcass is passed for food, the inspector shall stamp the retained tag "U. S. Inspected and Passed," and return the tag with his report to the inspector in charge.

**MARKING OF PRIMAL PARTS**

REGULATION 29.—On each primal part, or organ, or the container thereof, which has been inspected and passed, and which is to leave the establishment for interstate or export commerce, and which has not been theretofore marked with the words "U. S. Inspected and Passed" and the establishment number, there shall be placed, under the personal supervision of a Department employe, a mark, stamp, or brand bearing the words "U. S. Inspected and Passed" and the establishment number. When primal parts or organs are shipped between establishments at which inspection is maintained the number of the establishment need not appear.

**BRANDING IRONS**

**REGULATION 30.**—When hot branding irons or other instruments are used to label hams, bacon, or other primal part with the name of the packer, or with a trade-mark, and it is desired, in addition, to indicate that the meat has been inspected by the Department of Agriculture, the wording for this purpose, which shall be in letters and figures of sufficient size to be legible, shall include the number of the establishment in which the product was produced, and also the statement "U. S. Inspected and Passed," or the abbreviated statement "U. S. Ins. Psd." This marking shall be accepted as the United States inspection mark. It shall be affixed, however, only under the personal supervision of a Department employe.

**"SPECIAL" STAMP**

**REGULATION 31.**—Upon all meats and meat food products prepared for export with preservatives under Regulation 39, paragraph (b), there shall also be stamped or branded, under the personal supervision of a Department employe, the word "Special." This word "Special" shall not be used upon any inspected meats or meat food products not prepared under said Regulation 39, unless it is used in combination with other words.

**TRADE LABELS**

**REGULATION 32.**—Upon each can, pot, tin, canvas, or other receptacle or covering containing any meat or meat food product for interstate or foreign commerce, except packages on which meat-inspection stamps appear, there shall be placed, under the supervision of a Department employe, a trade label. This trade label shall contain the words "U. S. Inspected and Passed, under the act of Congress of June 30, 1906," in plain letters and figures of uniform size, the number of the establishment at which the meat or meat food product is last prepared or packed, and labeled, and the true name of the meat or meat food product contained in such package. Only trade names which are not false or deceptive may be used upon the trade label. A copy of each trade label shall be filed with the inspector in charge for his approval. The inspector in charge shall approve or disapprove each trade label, and report his action for approval to the Chief of the Bureau of Animal Industry, forwarding the label with his report. Only trade labels which have been approved by the Secretary of Agriculture shall be used.

**REGULATION 33.**—*False or Deceptive Names.*—No meat or meat food products shall be sold or offered for sale by any person, firm, or corporation in interstate or foreign commerce under any false or deceptive name; but established trade name or names which are usual to such products and which are not false and deceptive, and which

shall be approved by the Secretary of Agriculture, are permitted. Trade labels which are false or deceptive in any particular shall not be permitted. A meat food product, whether composed of one or more ingredients, shall not be named on a trade label with a name stating or purporting to show that the said meat food product is a substance which is not the principal ingredient contained therein, even though such name be an established trade name.

#### **TAGGING REINSPECTED MEATS AND MEAT FOOD PRODUCTS**

**REGULATION 34.**—Upon all meats or meat food products, which are suspected on reinspection of being unsound, unhealthful, unwholesome, or otherwise unfit for human food, or upon the containers thereof, there shall be placed by a Department employe at the time of reinspection the "U. S. Retained" tags hereinbefore described. The employe who affixes the tag shall send the numbered stub with his report to the inspector in charge. These tags shall accompany the said meats or meat food products to the retaining room or other special place for final inspection. When the final inspection is made, if the meat or meat food product be condemned the "U. S. Retained" tag shall be stamped "U. S. Inspected and Condemned," and shall accompany the condemned meat or meat food product to the tank.

Immediately before the meat or meat food product is tanked the employe supervising that operation shall write or stamp the word "Tanked" and the date upon the said tag, and sign his name thereto, and forward the tag to the inspector in charge with his report. If, however, upon final inspection, the meat or meat food product is passed for food, the inspector shall stamp the retained tag "U. S. Inspected and Passed," and return the tag with his report to the inspector in charge.

#### **REFERENCE TO UNITED STATES INSPECTION**

**REGULATION 35.**—Except as provided in these regulations, no reference to United States inspection shall appear upon any meat or meat food product or the container thereof.

#### **REINSPECTION**

##### **REINSPECTION OF PASSED CARCASSES AND PARTS**

**REGULATION 36.**—Before being admitted into any cooking, canning, sausage, or other department of an establishment, also before being packed for shipment, and at such other times as may be deemed necessary, all dressed carcasses or parts thereof that have been previously inspected and passed shall be reinspected by an inspector or his assistants, and if upon any such reinspection any carcass or part thereof is found to have become unsound, unhealthful, unwholesome, or in any way unfit for human food, the original mark, stamp, tag, or label shall be removed or canceled and the carcass or part shall be condemned.



**REINSPECTION OF INSPECTED MEATS RECEIVED  
AT OFFICIAL ESTABLISHMENTS**

**REGULATION 37.**—Except as provided in Regulation 41, only carcasses and parts thereof, meats, and meat food products which can by marks, seals, brands, or labels be identified as having been previously inspected and passed by a Department employe shall be taken into or allowed to enter an establishment at which inspection is maintained. All such carcasses, parts, meats, and meat food products which are brought into one establishment from another, or which are returned to the establishment from which they issued, shall be identified and reinspected at the time of receipt, and shall be subject to further reinspection in such manner and at such times as may be deemed necessary. If upon any such reinspection any carcass or part thereof, or meat or meat food product, is found to have become unsound, unhealthful, unwholesome, or in any way unfit for human food, the original mark, stamp, tag, or label shall be removed or canceled and the carcass, part, meat, or meat food product shall be condemned.

(a) Special docks and receiving rooms shall be designated by the establishment for the receipt and inspection of meats or meat food products, and no meats or meat food products shall be allowed to enter the establishment by any other docks or receiving rooms, and only in the presence of a Department employe.

**MARKING PASSED CARCASSES OR PARTS**

**REGULATION 38.**—All carcasses and parts of carcasses found upon inspection to be sound, healthful, wholesome, and fit for human food which leave the establishment where they are prepared for interstate or foreign commerce shall be designated by a mark, stamp, tag, or label bearing the words "U. S. Inspected and Passed," and no carcass, part of a carcass, or meat food product which has not been so designated shall be admitted to the canning, sausage, or any other department of any establishment where inspection is maintained other than the establishment in which it was prepared, except as provided in Regulation 41.

**DYES, CHEMICALS, AND PRESERVATIVES**

**REGULATION 39.**—(a) No meat or meat food product for interstate commerce, or for foreign commerce except as hereinafter provided, shall contain any substance which lessens its wholesomeness, nor any drug, chemical or dye (unless specifically provided for by a Federal statute), or preservative, other than common salt, sugar, wood smoke, vinegar, pure spices, and, pending further inquiry, saltpeter. Inspection and sampling of prepared meats and meat food products by Department employes shall be conducted in such manner and at such



times as may be necessary to secure a rigid enforcement of this regulation.

(b) In accordance with the direction of the foreign purchaser or his agent, meats and meat food products prepared for export may contain preservatives in proportions which do not conflict with the laws of the foreign country to which they are to be exported.

When such meats or meat food products are prepared for export under this regulation they shall be prepared in compartments of the establishment separate and apart from those in which meats and meat food products are prepared according to paragraph (a) of this regulation, and such products shall be kept separate and shall be labeled with special trade labels, approved by the Secretary of Agriculture, and indicating that such products are for export only. Special export certificates will be issued for meats and meat food products of this character, and, if the products are not exported, under no circumstances shall they be allowed to enter domestic trade.

### PREPARATION OF MEATS AND MEAT FOOD PRODUCTS

REGULATION 40.—All processes used in curing, pickling, preparing, or canning meats and meat food products in establishments where inspection is maintained shall be supervised by Department employes, and no fixtures or appliances, such as tables, trucks, trays, vats, machines, implements, cans, or containers of any kind, shall be used unless they are clean and sanitary, and all steps in the process of manufacture shall be conducted carefully and with strict cleanliness.

(a) *Cured Meats*.—Only meats which bear the mark "U. S. Inspected and Passed," or meats in containers which are so marked, and which upon reinspection are found to be sound, healthful, wholesome, and fit for human food, shall be taken into any meat-curing establishment where inspection is maintained. Any meats which upon reinspection are found to have undergone changes which render them unsound, unclean, unhealthful, unwholesome, or otherwise unfit for human food, shall be condemned and disposed of as provided in Regulation 18.

No drug, chemical, or coloring matter shall be used in any process of curing any meats, except as provided in Regulation 39. All pickling fluids and other solutions or substances used in curing meats must be clean. At the time that cured meats are packed for shipment in interstate or foreign commerce they shall be inspected by a Department employe, and any pieces or portions of such meats which are found to have undergone changes which render them unclean, unsound, unhealthful, unwholesome, or otherwise unfit for human food, shall be condemned and disposed of as provided in Regulation 18.

(b) *Sausages and Chopped Meats.*—All meat entering a sausage establishment where inspection is maintained shall be inspected by a Department employe when received. No meats which have not been inspected and passed under these regulations at the time of slaughter, or which, having been so inspected and passed, are found upon reinspection by a Department employe to have undergone changes which render them unsound, unclean, unhealthful, unwholesome, or otherwise unfit for human food, shall be employed in the preparation of sausages, chopped meats, or similar meat food products. Meats or meat food products which are found to have undergone these changes shall be condemned and disposed of as provided in Regulation 18. All meat trimmings for sausage shall be carefully inspected and assorted under the supervision of employes of the Department. No drug, chemical, preservative, or coloring matter shall be placed in or upon sausages or chopped meats for interstate or foreign commerce, except as provided in Regulation 39. The curing of sausages or chopped meats or similar meat food products shall be carried out in the manner prescribed for other meats in section (a) of this regulation.

(c) *Canned Products.*—All meats or meat food products entering a canning establishment shall be inspected by a Department employe when received. No meat which has not been inspected and passed at the time of slaughter under these regulations, or which, having been inspected and passed, is reinspected by a Department employe and found to have undergone changes which render it unclean, unsound, unhealthful, unwholesome, or otherwise unfit for human food, shall be allowed to enter into the preparation of canned meats or canned meat food products. No drug, chemical, or coloring matter shall be used in canned meats or meat food products for interstate or foreign commerce, except as provided in Regulation 39.

If at any time during the handling of any meat or meat food product, or at any time after the packing or canning of any such product, any portion or package shall be found to be unwholesome, unhealthful, or otherwise unfit for human food, such portions or packages shall be condemned and disposed of in the manner prescribed in Regulation 18.

No meat food product which has passed through the various processes of canning shall be removed from the container and recooked, resterilized, or repacked, except under the supervision and with the approval of a Department employe.

REGULATION 41.—*Rendering of Lard and Tallow.*—The rendering of all fats into lard, tallow, oils, and stearin at establishments where inspection is maintained shall be closely supervised by employes of the Department. All portions of carcasses rendered into lard and tallow must be clean and wholesome. Tanks and vats used for rendering condemned carcasses and refuse products must not be connected in any manner with tanks, vats, or other receptacles used for lard or other edible products. Unmelted fat which is not marked or stamped

“U. S. Inspected and Passed” and which upon inspection is found to be sweet, clean, and of healthful appearance may be received, inspected, and rendered at a temperature not lower than 170° F. for one hour.

## STAMPS, STAMPING, AND CERTIFICATES

### STAMPS

REGULATION 42.—Numbered meat-inspection stamps shall be affixed to packages containing meats or meat food products to be shipped or otherwise transported in interstate or foreign trade. No reference to United States inspection other than that contained on the meat-inspection stamp shall appear on any such package.

REGULATION 43.—*Protection for Stamps*.—Stamps shall be affixed in the following manner, and when they have been affixed they shall be covered immediately with a coating of transparent varnish or other similar substance.

(a) The stamp may be affixed in a grooved space, made by removing a portion of the wood, of sufficient size to admit the stamp.

(b) The stamp may be placed on either end of the package, provided that the sides are made to project at least one-eighth of an inch to afford the necessary protection from abrasion.

REGULATION 44.—*Destruction of Used Stamps*.—Whenever any package of meats or meat food products bearing the meat-inspection stamp shall have been opened and its contents removed for sale the stamp on said package shall be immediately defaced and destroyed.

### CERTIFICATES FOR EXPORTS

REGULATION 45.—The inspector in charge of an establishment shall issue certificates of inspection for all carcasses of cattle, sheep, swine, and goats, and the meats or meat food products thereof, which are to be exported to foreign countries. Each certificate shall cite the name of the shipper, the name of the consignee, the destination, the establishment number or numbers on the labels, the numbers of the stamps attached to the article to be exported, and the shipping marks. These certificates shall be issued in serial numbers and in triplicate form. Only one certificate shall be issued for each consignment unless otherwise directed by the Chief of the Bureau of Animal Industry.

Both the original and duplicate certificates shall be delivered to the exporter. The original is to be attached to the bill of lading accompanying the shipment for the information of the customs authorities, and shall be delivered to the chief officer of the vessel upon which said consignment is to be transported, and continue with the shipment to destination. The duplicate shall be forwarded by the consignor to the consignee, to be used by the latter in identifying the shipment at the point of destination by comparison with the original.

### **COUNTERFEITING, ETC.**

**REGULATION 46.**—It is a misdemeanor, punishable by fine and imprisonment, for any person, firm, or corporation, or officer, agent, or employe thereof, to forge, counterfeit, simulate, or falsely represent, or without proper authority to use, fail to use, or detach, or knowingly or wrongfully to alter, deface, or destroy, or to fail to deface or destroy, any of the marks, stamps, tags, labels, or other identification devices provided for by the law or by these regulations, on any carcasses, parts of carcasses, or the food product, or the containers thereof, or wrongfully to use, deface, or destroy any certificate provided for by law or these regulations.

### **REPORTS**

**REGULATION 47.**—Reports of the work of inspection carried on in every establishment shall be daily forwarded to the Department by the inspector in charge, on such blank forms and in such manner as may be specified by the Chief of the Bureau of Animal Industry. The proprietors of establishments at which inspection is maintained shall furnish daily to the Department employes detailed to the various departments accurate information regarding receipts, shipments, and amounts of products on which to base their daily reports.

Weekly reports on sanitation shall be made by the Department employes in charge of the various departments to the inspector in charge of the station, and by the inspector in charge to the Chief of the Bureau of Animal Industry. If any insanitary conditions are detected by any Department employe such conditions shall be reported immediately to the inspector in charge, who, after investigation, shall report them to the Chief of the Bureau.

### **APPEALS**

**REGULATION 48.**—When the action of any inspector in condemning any carcass or part thereof, meat, or meat food product is questioned, appeal may be made to the inspector in charge, and from his decision appeal may be made to the Chief of the Bureau of Animal Industry or to the Secretary of Agriculture, whose decision shall be final.

### **COOPERATION WITH MUNICIPAL AUTHORITIES**

**REGULATION 49.**—All inspectors in charge are directed to notify the municipal authorities of the character of inspection, and to cooperate with such authorities in preventing the entry of condemned animals, or their products, into the local markets.

The details of any such proposed cooperative arrangement must be first submitted to and approved by the Chief of the Bureau of Animal Industry.

**AMENDMENT NO. 1 TO B. A. I. ORDER NO. 137**

**REGULATION 50.**—Governs the examination and relabeling of meats and meat food products on hand, October 1, 1906, when this law went into effect.

**MEDICAL MEAT PRODUCTS**

**REGULATION 51.**—Products such as meat juice, meat extract, etc., which are intended only for medicinal purposes and are advertised only to the medical profession, are not considered meat food products within the meaning of B. A. I. Order No. 137 and this amendment.

**AMENDMENT NO. 2 TO B. A. I. ORDER NO. 137**

**REGULATIONS 52 TO 59.**—Govern the transportation of meat in interstate and foreign commerce.

A meat food product, within the meaning of the meat-inspection act and of these regulations made thereunder, is considered to be any article intended for human consumption which is derived or prepared from any portion of the carcass of cattle, sheep, swine, or goats, and which, when eaten, is capable of supplying nourishment or energy to the human body, or of repairing body waste. A mixture of which meat is an ingredient will not be considered a meat food product unless the meat contained therein is a definite and considerable portion of the said mixture, and Regulation 12 of B. A. I. Order No. 137 is hereby modified accordingly. But where such a mixture is prepared in an establishment where inspection is maintained, the sanitation of that portion of the establishment in which the said mixture is prepared will be supervised by the Department, and the meat or meat food product which enters the said mixture will be inspected before it enters the said mixture. The mixture will not be officially labeled. Mixtures such as mince meats, soups, etc., which come under this ruling and which are not officially labeled, are allowed in interstate and foreign commerce without inspection and without certificates, subject to the provisions and requirements of the pure-food law and the regulations made thereunder. Products such as meat juice, meat extract, etc., which are intended and used only for medicinal purposes, and which are advertised only to the medical profession, are not meat food products within the meaning of B. A. I. Order No. 137 and this amendment.

**AMENDMENT NO. 3 TO B. A. I. ORDER NO. 137**

**REGULATION 60.**—Governs the interstate and foreign transportation of meats and meat food products prepared with preservatives prior to October 1, 1906, and amends Regulation No. 45, governing the transportation to a foreign country of meats and meat food products.

**AMENDMENT NO. 4 TO B. A. I. ORDER NO. 137**

Amends Regulations 22, 23, 24, and 25, governing the labeling of carcasses in establishments where inspection is maintained; amends Regulation 41, governing entrance of unmarked fats into establishments where inspection is maintained; and amends Regulation 50, governing the examination and relabeling of meats and meat food products on hand, October 1, 1906.

REGULATIONS 22, 23, 24, AND 25.—These regulations are amended to permit the placing, under the personal supervision of a Departmental employe, of labels upon carcasses by employes of establishments at which inspection is maintained.

REGULATION 41.—This regulation is amended to read as follows. The new matter is italicized.

“REGULATION 41.—*Rendering of Lard and Tallow.*—The rendering of all fats into lard, tallow, oils, and stearin at establishments where inspection is maintained shall be closely supervised by employes of the Department. All portions of carcasses rendered into lard and tallow must be clean and wholesome. Tanks and vats used for rendering condemned carcasses and refuse products must not be connected in any manner with tanks, vats, or other receptacles used for lard or other edible products. Unmelted fat *from carcasses which have been U. S. inspected and passed and so marked*, which is not marked or stamped ‘U. S. Inspected and Passed,’ and which upon inspection is found to be sweet, clean, and of healthful appearance, may be received, inspected, and rendered at a temperature not lower than 170° F. for one hour.’

**AMENDMENT NO. 5 TO B. A. I. ORDER NO. 137**

REGULATION 61.—Governs the interstate transportation of inspected and passed meats and meat food products which are alleged to be or have become unfit for food, and restricts their admission into establishments where inspection is maintained.

**AMENDMENT NO. 6 TO B. A. I. ORDER NO. 137****REGULATIONS GOVERNING THE USE OF DYES, CHEMICALS,  
AND PRESERVATIVES**

REGULATION 39.—(a) No meat or meat food product for interstate commerce, or for foreign commerce except as hereinafter provided, shall contain any substance which lessens its wholesomeness, or any drug, chemical, harmful dye, or preservative, other than the preservatives common salt, sugar, wood smoke, vinegar, pure spices, and, pending further inquiry, saltpeter. No dye, unless specifically authorized by a Federal statute, shall be used in any meat food product pre-

pared for interstate or foreign commerce, until the use of such dye has been specifically authorized by the Secretary of Agriculture. The Department is conducting careful investigations into the effect of various dyes upon meat and meat food products, and, while the investigation of all dyes is not completed, it has been demonstrated that certain dyes do not render meat and meat food products unsound, unhealthful, unwholesome, or otherwise unfit for human food. The names of harmless dyes which may be used will be communicated to the inspectors in charge from time to time as the investigation progresses, and no meat or meat food product which contains a dye whose use has not been approved by the Secretary of Agriculture shall be marked "Inspected and Passed" or allowed in interstate or foreign commerce. Inspection and sampling of prepared meat and meat food products by Department employes shall be conducted in such manner and at such times as may be necessary to secure a rigid enforcement of this regulation.

(b) In accordance with the direction of the foreign purchaser or his agent, meat and meat food products prepared for export may contain preservatives in proportions which do not conflict with the laws of the foreign countries to which they are to be exported.

When such meat or meat food products are prepared for export under this regulation they shall be prepared in compartments of the establishment separate and apart from those in which meat and meat food products are prepared according to paragraph (a) of this regulation, and such products shall be kept separate and shall be labeled with special trade labels, approved by the Secretary of Agriculture, and indicating that such products are for export only. Special export certificates will be issued for meat and meat food products of this character, and, if the products are not exported, under no circumstances shall they be allowed to enter domestic trade.

The law permits the use, under the above restrictions, of preservatives in meat and meat food products for export, but does not permit the use of any dye or coloring matter not permitted in meats prepared for interstate trade. Neither is there in the law any authority for allowing a trade label for use in export trade which is not permitted in interstate trade.

#### **INSTRUCTIONS CONCERNING TRADE LABELS UNDER THE MEAT-INSPECTION LAW AND REGULATIONS**

The following instructions are intended, so far as possible, to cover the interpretation of the meat-inspection law regarding trade labels, and include tentative rulings made by the Pure Food Commission under the pure-food law. These tentative rulings of the Pure Food Commission are made known at this time by the Bureau of Animal Industry in



order that labels for meat food products may be prepared in conformity with both laws.

The essential features of a label must be placed together in any desired order without interspersing any descriptive, qualifying, or advertising matter. The essential features are as follows:

The true name of the product.

The true name of the manufacturer, if given.

The true name of the place of manufacture, if given.

The name of the manufacturer is not required under the meat-inspection or pure-food laws, but if given it must be the true name.

Persons, firms, or corporations owning subsidiary companies having legal entity may use the names of such companies, provided application has been made for inspection, and it has been granted; the inspection legend in such case to bear the establishment number of the parent firm or corporation.

The name of the place of manufacture, other than the establishment number embodied in the inspection legend; is not required under the meat-inspection law. The name of the place of manufacture is not required under the pure-food law, except in the case of compounds, mixtures, imitations, or blends.

The inspection legend "U. S. Inspected and Passed under the act of June 30, 1906," and the establishment number in plain characters of uniform size, which shall be in proportion to the general lettering of the label, must be separately and prominently embodied in all trade labels.

In the case of meats contained in cartons, or in wrappers of paper, cloth, or other similar substance, the inspection legend and establishment number may be embodied in a sticker or seal of proportionate size, prominently displayed with the trade label but not necessarily a part of the trade label, such stickers or seals to be approved by the Department of Agriculture. When a package is fastened by a seal, or other device, embodying the establishment number and the inspection legend, such seal shall also be approved by the Department.

The wording of all trade labels and the inspection legend embodied therein, and the wording on stickers or seals, must be in English; except that, if so desired, the name of the product may be inserted also in a foreign language as an explanation or translation of the English name; for example, "Lion Roll" or "Lachschinken."

*Export Labels and Brands.*—While labels to be affixed to goods for foreign shipment may be printed in a foreign language, the same rules shall apply with reference to false labeling and naming of ingredients as shall apply to goods prepared for domestic use. The meat-inspection law does not require boxes or barrels, except such as contain lard, to be stenciled or labeled, as these containers will be marked with an inspection stamp; but if they are labeled or stenciled it must be in accordance with the rules pertaining to labeling and stenciling domes-



tic meat food products. The inspection legend and establishment number must in all cases appear in English; but if desired they may, literally translated, appear in the language of the country to which the package is destined.

*False or Deceptive Names.*—No picture, design, or device which gives any false indication of origin or quality shall be used upon any label. Any statement, design, or device regarding the virtues or properties of the materials contained in the package that is false in any particular is prohibited by law; for example, the picture of a pig appearing on a label which is placed upon beef product; the picture of a chicken appearing upon a label placed upon product composed of veal or pork; the picture of a leaf or leaves appearing in connection with the word "Lard" is considered deceptive, except that when used on packages containing leaf lard it may appear separately from the word "Lard" as a brand; e. g., "Maple Leaf Brand." Such words as "Special," "Superior," "Fancy," "Selected," etc., placed upon products which are more inferior than implied by the term used are false and deceptive.

*Geographical Names.*—Geographical names may be used only with the words "Cut," "Type," "Brand," or "Style," as the case may be, except upon foods produced or manufactured in the place, State, Territory, or country named; for example, "Virginia Ham" not produced in Virginia must be marked "Virginia Style Ham"; "English Brawn" must be "English Style Brawn"; "English Sausage" should be "English Style Sausage"; "Bologna Sausage" should be "Bologna Style Sausage"; "Frankfurter Sausage" should be "Frankfurter Style Sausage"; "Cumberland Middles" should be "Cumberland Cut Middles"; "Winchester Sausage" or "Winchester Ham" should be "Winchester Brand Sausage" or "Winchester Brand Ham," etc.

*Names of Breeds of Live Stock and Names of Persons.*—Names indicative or imitative of distinctive types or breeds of live stock cannot be used unless the product is actually made of the meat from animals of those breeds; for example, "Berkshire Pork" cannot be used unless the product is from the Berkshire breed of hogs.

Names of persons when used as brands or applied to cuts will not be considered deceptive.

*Products Prepared for Another Establishment.*—When an article is prepared by an establishment for another firm or individual, if the name of the said firm or individual is to appear upon the label, the statement must be made that the article was "prepared for" or "manufactured for" the firm or individual. Names of subsidiary companies which have legal entity may be used without the prefix "prepared for" or "manufactured for"; and such subsidiary companies must make application for inspection under the establishment number of the parent organization. The name of a firm or individual may appear as the distributor of the product.

*Ham.*—The word “Ham” without a prefix indicating the species of animal is considered to be a pork ham. Trimmings removed from the ham and used in the preparation of potted or prepared meats or sausage, or when used alone, may be known as “Potted Ham” or “Ham Sausage.” The word “Ham” cannot be used on any prepared ham product without some word clearly and truthfully indicating the method of preparation; thus, “Potted Ham,” “Deviled Ham,” “Minced Ham,” “Ham Sausage.”

*Tongue.*—No species of animal need be indicated; but if the species is specified, the statement must be true. In connection with the preparation of tongue products, the rulings will be the same as those in connection with the preparation of ham products; for example, “Potted Tongue” must be made of tongue or tongue trimmings.

#### EXAMPLES

##### HAM, TONGUE, SHOULDER, ETC.

*Potted, Deviled, Minced, or Otherwise Prepared Ham.*—Name considered false or deceptive unless product is actually made of ham or ham trimmings. If any other pork is used the mixture can be called “Pork Meats” or “Potted Meats.”

*Potted, Deviled, Minced, or Otherwise Prepared Tongue.*—Must be made only of tongue or tongue trimmings.

*Picnic Hams.*—Cannot be called “Hams”; may be called “Picnics” or “Picnic Shoulders.”

*California or Cala Hams.*—Cannot be called “Hams”; may be called “Calas.”

*Boneless Hams, as Applied to Shoulder Butts.*—May be called “Boneless Picnics” or “Boneless Butts.”

*Cottage Hams.*—May be called “Cottage Style Ham Sausage,” if made from ham or ham trimmings.

*Dewey Ham.*—Is a loin. May be called “Dewey Loin”; cannot be called “Ham.”

*Westphalia Ham.*—May be called “Westphalia Style Ham.”

*York Ham.*—May be called “York Cut Ham” or “York Style Ham.”

*New York Shoulder.*—May be called “New York Style Shoulder.”

*English Cured Ham.*—May be called “English Style Cured Ham.”

#### SAUSAGE

*Pork Sausage.*—Cannot be so called unless made from pork meat only.

*Little Pig Sausage.*—May be called “Little Pork Sausage” or “Pigmy Sausage.”

*Farm Sausage.*—Call “Farm Style Sausage.”

*Bologna Sausage.*—Call “Bologna Style Sausage.”

*Oxford Sausage.*—Call “Oxford Style Sausage.”

*Vienna Sausage.*—Call “Vienna Style Sausage.”

*Frankfurt Sausage or Frankfurter Sausage.*—Call "Frankfurt Style Sausage," or "Frankfurter Style Sausage."

*Liver Sausage or Blood Sausage.*—Names of other ingredients must be shown.

#### LARD, ETC.

*Pure Lard.*—Must be made of sweet, clean, clear hog fat. The addition of not to exceed 5 per cent. of clean, sweet lard stearin is allowed.

*Leaf Lard.*—Must be made wholly from leaf fat of hogs, without the addition of fat from any other portion of the carcass.

*Kettle Rendered Lard.*—Must be actually rendered in an open or closed kettle, without the addition of pressure or contact of live steam with the product.

*Open Kettle Rendered Lard.*—Must be actually rendered in an open kettle, as above.

*Country Lard.*—Must be made in the country in an open kettle; can be called "Country Style Lard," if rendered in an open kettle.

*Home Made Lard.*—Call "Home Made Style Lard."

*Lard Compound.*—The pure lard must be equal to or greater than any other one ingredient.

#### OTHER PRODUCTS

*Roast Beef or Roast Mutton.*—May be used provided a description of the method of preparation appears in letters of prominent size in connection with the words "Roast Beef" or "Roast Mutton."

*Rump Steak.*—Cannot be so called unless made from rump steak only.

*Minced Steak.*—Clearly a misnomer, unless made from steaks.

*Brawn.*—Cannot be so called unless made from pork only.

*Veal Loaf.*—Cannot be so called unless the meat used is veal only.

*Extract of Beef.*—Must be actually made from beef.

*Mixtures and Compounds.*—Mixtures, when the name plainly indicates a mixture, such as "Sausage," "Hash," "Mince," etc., need not be marked "Compound." Other mixtures not so indicated by their names must be marked "Compound." In the case of compounds containing lard, stearin, or other fats, or cotton-seed oil, and in compounds containing stearin and cotton-seed oil, the names of the ingredients must appear upon the label. If the compound has a distinctive name, such as "White Cloud," "Cottolene," "Cottosuet," etc., the word "Compound" need not appear, but the ingredients must be stated upon the label. When the word "Compound" is used it cannot be qualified by any adjective either before or after, nor can the name of any product be attached to the word "Compound," unless that product is the principal ingredient of the compound.

Unless mince meat, or pork and beans, or soups contain a considerable proportion of meat, they will not be considered meat food products.

*Sausages and Chopped Meats.*—The word “Sausage” without a prefix indicating the species of animal is considered to be a mixture of minced or chopped meats, with or without spices. If any species of animal is indicated, as “Pork Sausage,” the sausage must be wholly made from the meat of that species. If any flour or other cereal is used, the label must so state. If any other meat product is added the label must so state; for example, “Pork and Beef Sausage,” “Pork, Beef, and Flour” (or other cereal), or “Pork and Beef Sausage, Cereal Added.”

Meat loaves, without a prefix indicating any particular kind of meat, are held to be mixtures of meats, flour (or other cereal), milk, eggs, butter, or other ordinary loaf ingredients. If any particular kind of meat is indicated, that kind must be the only meat used; for example, “Veal Loaf” must be made from veal and loaf ingredients only. If any other meat is used the label must so state; for example, “Veal and Pork Loaf”; “Veal, Beef, and Pork Loaf.”

The word “Paté” is synonymous with “Loaf.”

*Flour* or other cereals may be used in the preparation of loaves, gravies, or soups without being stated on the label.

*Canned Products.*—If flour or other cereal is used in any canned product which is not labeled “Loaf,” “Paté,” or “Soup,” or which is not prepared with gravy, the label must clearly show the presence of the flour or other cereal.

#### LARD, LARD COMPOUNDS, AND LARD SUBSTITUTES

All tins, pails, tierces, or other true containers of lard, lard compounds, or lard substitutes must be so marked as to clearly indicate the ingredients from which made.

*Leaf Lard.*—Leaf lard must be made from the leaf fat only, and no other part of the hog fat can be added thereto.

*Kettle Rendered Lard.*—Kettle rendered or kettle lard may be rendered in either open or closed kettles, not under pressure, and no live steam must come in contact with the product. When labeled “Open Kettle Rendered,” it must be rendered in an open kettle.

*Lard and Lard Stearin.*—Pure lard, made from sweet, clear, and clean hog fat to which not to exceed 5 per cent. of pure, sweet lard stearin has been added, may be labeled “Pure Lard.” If lard contains more than 5 per cent. of added lard stearin, or any per cent. of other stearin, the addition must be so stated on the label, with the name of the kind of stearin used; for example, “Pure Lard with Lard Stearin Added,” or “Pure Lard with Oleo Stearin Added,” or “Lard with Oleo Stearin Added,” or “Lard With Tallow Added.” When the word “Pure” is used in connection with the word “Lard,” the lard must be made only from sweet, clean, clear hog fat. In all such cases the lard must equal or exceed in quantity the added animal fat. The words “Pure Lard with . . . . . Added” cannot be used when any ingredient

other than pure, clean animal fat is added. The percentage of added stearin or other animal fat may be given if desired.

*Lard Compounds.*—A substance composed of lard, stearin, or other animal fat and a vegetable oil may be labeled "Lard Compound," but in such case the names of all the ingredients must be shown upon the label; and in all cases the proportion of lard must be equal to or greater than any other one of the ingredients.

*Compounds, or Lard Substitutes.*—In compounds, or lard substitutes, if the compound has a distinctive name, the distinctive name may be used without the word "Compound," and in all cases the ingredients must be stated on the label. In all cases only sweet and clean edible stearin and sweet and clean edible fats shall be used.

The prepuces, bladders, etc., shall not be used in edible food products.

The above rulings do not exempt packers or manufacturers from the enforcement of State laws.

### MEAT INSPECTION RULINGS—1 A

The following rulings under the Meat Inspection Law and the Regulations made thereunder have been announced by the Department of Agriculture.

Transportation, etc. is the subject of the first ruling.

#### CASINGS

1. Unfilled "casings" shall be regarded as containers and not as meat food products, but when such casings are to be exported to a foreign country which requires a certificate showing that the casings are products of animals which were free from contagious disease at time of slaughter the necessary stamps and a certificate will be issued by the inspector in charge.

#### LABELS

1. Labels or stickers, bearing the inspection legend, separate and apart from the trade label, may, under the supervision of a Department employe, be used on inspected and passed meats which are wrapped in paper or cloth or which are placed in pasteboard containers. But no such label or sticker, bearing an inspection legend, can be used in establishments where inspection is not maintained.

2. Products not classed as "meat food products," which are prepared at establishments where inspection is not maintained, and which contain small quantities of meat which have been inspected and passed under the meat inspection law, and no other meats, may bear a label with a personal statement of the manufacturer that the meat contained therein has been inspected and passed at an establishment where inspection is maintained. In each such case, however, the label before being used must be submitted to the Chief of the Bureau of Animal Industry for approval.

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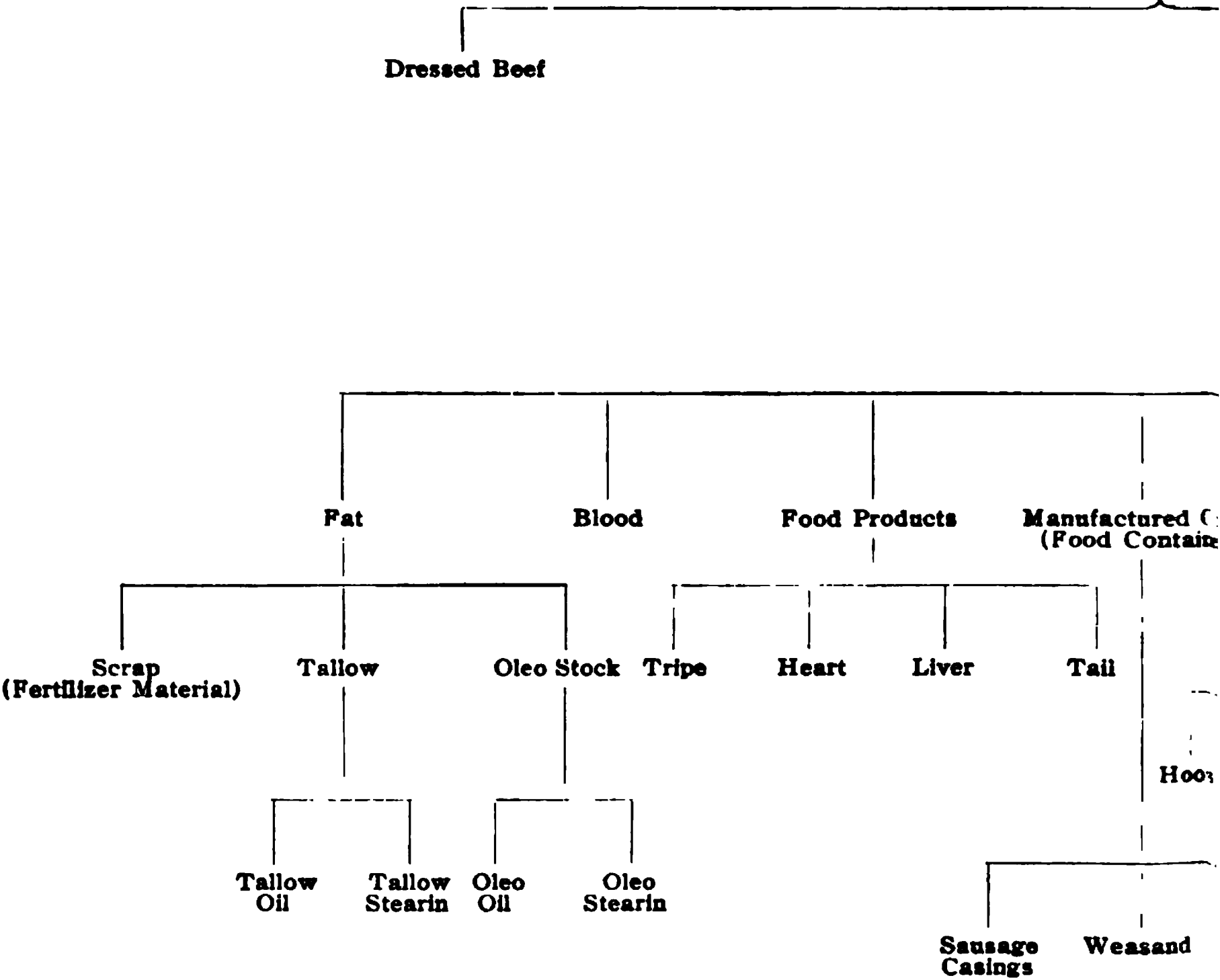
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**THE DISPOSITION OF A BULL**

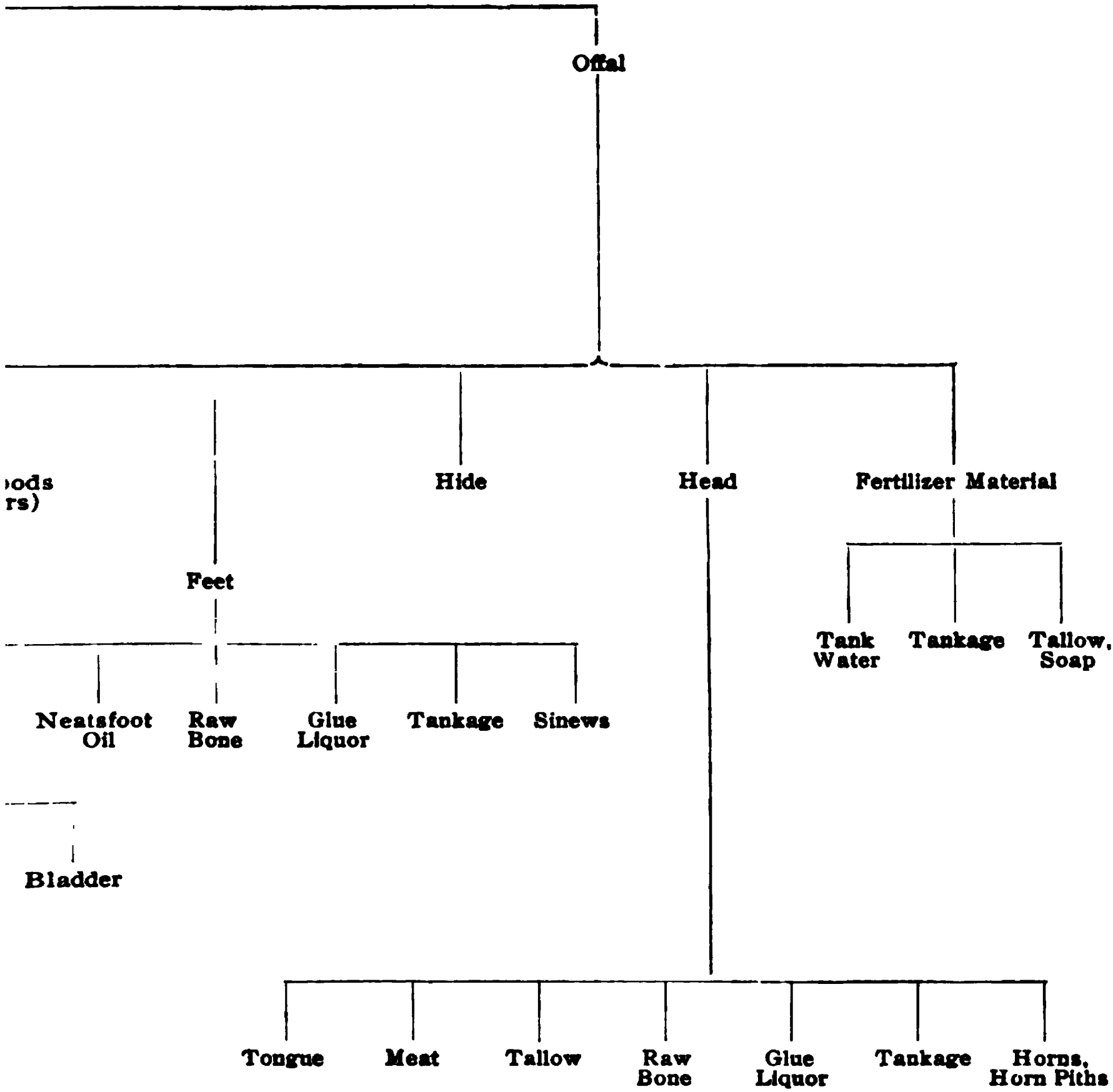
**A Bullock Y**



**FIG. 1**

WEEK IN THE PACKING HOUSE

ends



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Bladder





3. No label will be approved for use which contains an incorrect or false statement of the weight of the package; or which does not show that the weight, if given, is net or gross.

#### DEFINITIONS

1. When the words "meat" or "meat food products" are used in the regulations or rulings of the Secretary of Agriculture they mean meat or meat food products of cattle, sheep, swine, or goats, and do not include meat or meat food products of other animals.

2. Nonedible grease and nonedible tallow, derived from cattle, sheep, swine, or goats, are not considered meat food products. However, when nonedible grease and nonedible tallow are to be exported to a country for which the requirement of a certificate has not been waived, the collectors of customs, under instructions from the Secretary of Commerce and Labor, will require an affidavit from the exporter that the grease and tallow to be exported are nonedible and not intended for food purposes.

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## VARIOUS ANIMAL PRODUCTS AND THEIR DISPOSITION

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### BEEF PRODUCTS

10. The disposition of a bullock in the modern packing house is quite complex. To obtain the best financial results, the operations of caring for the various by-products are carried out in great detail. By referring to the chart, Fig. 1, it will be seen into what products a bullock is ordinarily resolved. It is important for a chemist dealing with animal products to know the source and nature of material with which he has to deal. Further than this, knowing the characteristics of certain products, he can very often, by a superficial examination of material in question, at once name the source of its derivation.

This is especially true of tallow and lard. Certain parts of animal fats have, as is well known, different melting points. For example, the tallow obtained from a bullock's head will have a titer, or hardness, not exceeding 41.5° or 42° C., while the tallow from the small intestines will have one of about 44° C. When an ordinary tallow is found with a hardness

of over 44° C., the origin is at once placed to the fat of the kidneys.

11. The resolution of the bullock will be treated first, that of the hog following. While the chart, Fig. 1, shows the detail in a general way, some of the by-products are still further subdivided. The method of handling in the particular packing house determines this. For example, as shown in the chart, the feet, among other things, yield sinews, neatsfoot oil, and raw bone. Taking these products, it is possible, by further treatment of sinews, to obtain glue, neatsfoot oil, and tankage. From the neatsfoot oil may be obtained cold-pressed neatsfoot oil and neatsfoot stearin. From the raw bone may be obtained gelatine, glue, tallow, and bone meal. Thus, while the chart represents approximately the ultimate disposition of the by-products, it should be remembered that further treatment is frequently practiced, even to the finished stage, as previously mentioned; also, that not all these many by-products are made in all establishments. As the present conditions in this business, however, demand the utilization in the same plant of everything possible, the treatment of each product will be described.

12. **Hide.**—The hide is the most valuable by-product of the bullock. It is removed from the freshly slaughtered bullock, and after being trimmed free from adhering flesh and fat, is allowed to cool for at least 24 hours to eliminate the animal heat. If this were not done and the hide salted while more or less warm, decomposition would ensue to some extent, which, while held in check by the salt, would so injure the fiber of the hide that the tanner would be unable to make it into good leather. When such decomposition takes place, it also destroys the epidermis of the hide, causing more or less of the hair on the hide to come off in patches, and thus making a "hair-slipped" hide, much deteriorated in value.

Each hide, depending on the size, has from 25 to 30 pounds of coarse salt spread over it, and the hides are piled, one on top of the other, to a height of about 3 feet. These packs in the

large packing houses contain from 1,000 to 3,000 hides each. They are allowed to remain in this condition until cured, which generally requires about 3 weeks. The hides are then termed *green-salted hides* and are sold in this condition. Several grades are selected in the packing house, varying according to weight, brand, size, and general condition.

During the period of curing, considerable shrinkage in weight takes place. The amount of such shrinkage depends on the length of time the hides are held, on the condition of the hides when put down, and on the degree of moisture of the hide cellar. There is also a marked difference in the shrinkage of hides at different times of the year, varying from about 14.3 to 15.8 per cent.

**13. Head.**—After removal from the body, the head is trimmed free from meat, which is utilized in the making of sausages and for canning. Owing to the very gelatinous, or glutinous, character of this "head meat," it is valuable also for use in making various other food products, as "loaf," etc., in combination with other materials.

If there are any horns on the head, they are sawed off. Horns constitute a very profitable by-product of the packing house, as they bring good prices. Inside the horn is a tough, porous, semibony filling termed *horn pith*, which is an excellent material for the making of high-grade edible gelatine. The piths are removed from the horns by means of hot water and are dried carefully.

**14.** The head is then separated into the skull and the jaw bone. The brain is removed from the skull, if desired for edible purposes, and the skull is then placed in a vat of hot water. The jaw bone is cracked, so that the tallow contained in it can be boiled out, and is then placed in the vat with the skull. After accumulating a quantity of bones in this manner, they are washed, so as to remove the adhering blood and dirt, and boiled with live steam for about 10 hours. After this the vat is allowed a period of rest, to permit the tallow to rise. This treatment yields tallow, which is removed from the top of the liquor, and a watery solution

of glue, known as *glue liquor*, the treatment of which will be described later.

The bones remaining in the vat are removed and subsequently freed from adhering meaty matter, washed, and dried on steam coils. They may be disposed of in this condition or they may be crushed by a bone crusher and made into crushed raw bone, or the latter may be put through a bone mill and ground into raw-bone meal. An analysis of this will show, approximately, ammonia 5 to 5½ per cent. and bone phosphate 55 per cent.

The meaty material from the heads and the small, thin bones left behind, are then put into a rendering tank, to obtain whatever tallow may be left in them. The tallow obtained from heads is frequently called *butter stock*. It has a titer test of about 41.5° C., the free acid, if the heads have been cooked fresh, not exceeding .5 per cent. Formerly, this tallow was frequently used for the making of oleo oil and for mixing with lard. Under the new regulations, it may still be used for the former product, if suitable, but it cannot be mixed with pure lard, unless the fact is plainly stated on the label (see Art. 9).

**15. Tongue.**—The tongue is always removed before the head is manipulated for the other by-products. As this is one of the high-priced by-products of the animal, it is always handled to produce the best results in the way of weight, appearance, etc. Tongues are frequently sold in the fresh state; they are also, after the necessary preparation, sold in pickle.

After a period of curing in pickle, the tongues are often smoked after the manner of other smoked products and sold as smoked tongues. Differing from most of the by-products, the market demand for beef tongues is such that they never require to be tanked as surplus.

**16. Liver.**—The liver taken from the bullock has the gall bag removed and is then washed, hung on hooks to drain and chill thoroughly, and sold in the fresh state. Where a surplus of livers are obtained, they are tanked for fertilizer

material, making tankage that will analyze about 15 per cent. ammonia and no bone phosphate. Livers when cooked yield no tallow; when tanked and rendered with tallow material, they always discolor the resulting tallow.

**17. Heart.**—After removal, the heart is cut lengthwise to a slight extent, to allow the contained blood to escape from the interior. It is then washed in cold water, and when thoroughly chilled is used for canning, mixed with other meat; for pickled goods, similar to pigs' feet; for sausage; and very largely for the manufacture of beef extract. These processes will be described later. Hearts are also sold in the fresh state for food.

**18. Tail.**—The tail is chilled after removal from the bullock and is either sold fresh or utilized in the making of canned soups. At times the tails are chilled or frozen and exported. As they contain a large amount of gelatinous matter, they cannot be used for beef extract with any degree of success. With tails, as, in fact, with all surplus of packing-house by-products when beyond the proper condition for food, the fertilizer tank is their ultimate disposition.

**19. Tripe.**—In making tripe, the first stomach, or paunch of the bullock, containing the undigested food, is utilized. This undigested food is removed and utilized for the making of strawboard. To illustrate the progress in the utilization of the various wastes of the packing house, it is not many years since the packers paid for having paunch manure hauled away from the premises. Later, it was run through large rollers, to remove all juices and moisture possible, and then mixed with coal and burned as fuel. At the present time, practically the entire output is utilized for the manufacture of strawboard, as just stated. The fertilizing value of this paunch manure is very slight, as it contains when dried only 2 per cent. of ammonia; its low specific gravity and bulkiness make it undesirable for fertilizer mixtures.

The paunch itself is washed in ice-cold water and all adhering fat is trimmed off. This fat when rendered makes

a hard tallow, having a titer of about 44° C., and has always a greenish-yellow color. The free fatty acids in this tallow are usually about 1 per cent. The material is used either for oleo oil or for mixing with other common tallow. The cleaned paunch is cooked in hot water at a temperature just under boiling for about 2 hours and is then scraped free from the outside skin. After thoroughly cleaning all parts and trimming away all ragged edges, blemishes, etc., the paunch is again washed in water and allowed to cool. It is then placed in vinegar and sold as tripe. Tripes when tanked yield  $2\frac{1}{2}$  per cent. of tallow,  $7\frac{1}{2}$  per cent. of dried tankage, and about 9 per cent. of dry glue, obtained from the glue liquor. The tankage will analyze, on the dry basis, as follows: ammonia, 15 per cent.; ash, 7.65 per cent.; and fat, 4.4 per cent. Tripes are seldom used as a source of glue material, owing to their greater trade value in other channels. Experiments have been made to convert tripes into leather, but without success.

**20. Sweetbreads.**—The sweetbread is the thymus gland of the animal and is characteristic of comparatively young animals. In the older cattle, it practically disappears or becomes so shriveled as to be of no value. The weight of the full-sized sweetbread averages about  $\frac{1}{2}$  pound. Sweetbreads are always sold in the fresh state and are a very perishable product.

**21. Beef Gall.**—The beef gall, known in pharmacy as *fel bovis*, is frequently manufactured into inspissated ox gall. For this purpose, the gall is collected from the gall bladders and evaporated in an ordinary steam-jacketed kettle until a thick skin forms on the top of the liquor. The original bulk is reduced about three-fourths, when it is poured into shallow sheet-iron pans about  $1\frac{1}{2}$  inches high, 30 inches long, and 20 inches wide. At a temperature of 212° F., it is evaporated to dryness and kept in the drying room until wanted for grinding. As this material is very hygroscopic, this precaution is very essential.

The grinding, or powdering, is accomplished in a specially constructed mill, grinding out of contact with the atmosphere. Any machine that fills this condition is suitable for this purpose. The hard and brittle dried gall is removed from the pans only when wanted for immediate grinding. When sufficiently fine, the gall is removed from the mill and at once placed in tin cans, which are immediately sealed air-tight by soldering.

The inspissated ox gall is used to a considerable extent for medicinal purposes. The liquid gall is employed in the manufacture of special soap for washing goods, the dyes of which are loosely fixed. The liquid article is also used to a limited extent in fixing the dyes and colors of textile fabrics and carpets.

**22. Feet.**—In the packing house, the foot is that part of the leg from the knee joint to the hoof. After removal, the feet are stripped of the sinew lying along the shin bone. The sinews are, in most packing houses, salted down and kept in this condition until sold to the glue manufacturer. They may be cooked by themselves in the packing house, when they are resolved into glue liquor, yielding about 20 per cent. dry glue, 5 per cent. neatsfoot oil, and from 3 to 5 per cent. dry tankage (not including the large bones of the feet).

The feet are next passed to the bone sawyer, who removes the knee joint and the foot proper with the attached hoof, in both cuts exposing the marrow at the ends of the shin bone. The feet are then placed in boiling water for 15 minutes, removed, and the hoofs forced off by a machine known as the *hoof puller*, leaving them in condition to be boiled for oil, glue liquor, and bones. The hoofs are then either dried, to be sold in this condition, or made into hoof meal, which is described later.

The feet are put into open vats, washed free from blood, dirt, etc., and are then covered with clean water and cooked with live steam for about 10 hours, or until the bones fall apart and the oil separates. The glue liquor formed is



cared for by the glue department, when in connection with the packing house, or it may be concentrated to a jelly and sold in this condition to the glue manufacturer. The bones, washed free from adhering meaty matter, are dried in this condition as raw bone, or they may be ground into raw-bone meal, as will be described further on. The ends of the sawed shin bones are boiled with the feet, as they yield the same products. These ends are known as *knuckles*, and are utilized in the manufacture of bone black, as they are particularly adapted for this purpose.

23. The tankage, or refuse, from the boiled feet is generally recooked for several hours in order to obtain a further yield of oil. A set of feet (four) gives approximately  $\frac{1}{2}$  pound of dried, high-grade tankage. The oil that exudes from the feet in boiling is *neatsfoot oil*. This oil is collected from the vat, freed roughly from water and scrap by settling, and then placed in an open iron tank and heated to 220° F., to drive off all moisture contained in it. While hot, the oil is passed either through cotton-flannel bags or, where in large quantities, through a filter press, to remove fine scrap, hair, and other extraneous impurities. The oil when cool is ready for sale purposes as pure neatsfoot oil, or it may be further manipulated, being made into neatsfoot, stearin, and winter-pressed neatsfoot oil. The latter process will be described further on.

The sawed shin bones are also boiled in open vats with live steam, to prepare them for cutlery bones. The marrow of these bones also produces neatsfoot oil, which is mixed with that obtained from the knuckle bones of the feet. The refuse from the meaty matter of the bones is sent to the pressure tanks, to be further rendered with tallow material for any remaining fatty matter. The bones destined for cutlery purposes are cooked 5 or 6 hours at a temperature not exceeding 210° F., in order to retain as much of the gelatinous matter as possible, thereby keeping the strength of the bone more or less intact. It is important not to overcook these, as by so doing their value is reduced to that of

raw bone. In proper condition after cooking and drying, these bones are worth from \$50 to \$80 per ton. The cooked bones, freed from oil and tankage, are dried on racks at a moderate temperature, about 70° F., and are then ready for shipment.

The open tanks in which bones for cutlery purposes, etc. are boiled should be provided with a false bottom, either perforated or slatted, under which the usual steam pipes are placed. Otherwise, any bones lying directly against the live-steam pipes are liable to be discolored or overcooked, which are conditions that should always be avoided.

Where these shin bones are not handled in this manner, if not desired for fancy bones, the whole shin and foot, except the hoof, is boiled together for the production of neatsfoot oil and raw bone, the tankage, as usual, being incidental. Raw bones of this description furnish a most excellent raw material for glue and gelatine making.

**24. Manufactured Goods (Food Containers).—**Manufactured goods include material, always, even in small establishments, finished in the packing house for use in the business of the house or for sale. The most important of these articles are sausage casings. They, primarily, are the intestines of the bullock, and are treated most systematically, to obtain as clean and sterile a product as possible. Beef casings are divided into three kinds, namely, *rounds*, *middles*, and *bungs*. The bung is the large intestine of the bullock connecting the stomach with the smaller intestines, and varies in length from 4 to 8 feet, and from 3 to 5 feet when cured (salted). Beef middles, or casings, are the large intestines of the bullock. These vary in length from 20 to 38 feet. This intestine lies between, and is connected with, the bung gut and the round intestines, or "guts," as they are termed in the packing house. The round gut is the long intestine of the bullock, and varies in length from 100 to 140 feet.

These intestines lie connected with a mass of fat, the latter being a heavy, apron-like mass called the *ruffle*. The intes-

tines are subjected to thorough cleaning after separation from the fat, both inside and out, to remove contained manure and adhering slime, or mucus. The cleaning of intestines for the manufacture of sausage casings depends wholly on removing the impurities from the membrane, and is purely a matter of physical manipulation. The intestines after cleaning either by hand or by a casing-cleaning machine are covered with salt and bundled together for a few days to become cured, or impregnated with salt. They are then shaken free from salt, resalted with very fine salt, and packed in barrels and kegs for sale.

**25. Weasand.**—The weasand is the gullet, or lining of the throat, of the bullock, and is a tough, translucent membrane. It is surrounded by, or covered with, a layer of dark, soft meat, which is stripped off and utilized in the manufacture of beef extract or in making sausage. The weasands are then blown full of air and tied tightly. In this condition, with a 2-pound weight attached to the end of each one, they are hung up and allowed to dry for 24 hours at a temperature of 130° F., when they are removed from the drying room, one end cut off, and flattened out. They are then made up into bundles and sold in this condition. Both wide and narrow weasands are made, the former being blown to their full capacity and the latter only half distended with air.

**26. Bladder.**—The bladder is freed from urine, washed, and trimmed free from adhering fat, the latter being utilized for tallow. The bladder is then blown to its fullest extent with air, and a string is tied around its neck while in this condition. It is dried at the air temperature, the neck cut off, flattened out, and sold in bunches of dozens. Bladders are used extensively for the packing of putty. In England and Continental countries, they are sometimes used for the packing of lard and for various industrial purposes.

**27. Fat.**—From the bullock, three grades of fat are obtained. The best grade comprises the abdominal fat, or caul fat, the ruffle fat, and the fat from the top part of the

heart. This is all known as *No. 1 fat*, and is used for the manufacture of the best grades of oleo oil and oleo stearin, the manufacture of which will be described later. Next to the hide, this fat is the most important by-product. It is technically termed *butter fat*, as it is almost wholly used for making oleo oil and oleo stearin, the former article being one of the chief ingredients of butterine. The average bullock will yield from 60 to 75 pounds of this fat.

The next grade is fat, clean, but in small pieces, and mixed with other material, as meat and bones. This fat is washed in the tank for rendering and makes the ordinary tallow of trade. This tallow may be further separated into tallow oil and tallow stearin, the manufacture of which will also be described later.

The lowest grade of fat is that intimately mixed with dark-colored offal, or material that, when cooked, imparts an irremovable dark-greenish color to the resultant tallow. This rendered tallow is known as *No. 2 tallow*, and is always of dark color and strong, fetid odor. The free fatty acids in this material may reach 30 per cent., but usually are in the vicinity of from 12 to 18 per cent. Beef material and offal of no use for anything but fertilizer, together with cooked livers and lungs, furnish this grade of tallow, which is naturally of non-edible quality.

At times, other grades of tallow are made, such as edible tallow. This is made from any sweet and clear fatty material, particular care being exercised throughout its preparation. Edible tallow is employed for admixtures in lard and cooking compounds, etc.

All fats derived from direct slaughtering are known in the packing house as "killing fat," in distinction from the "cutting fat" derived from the cutting up and trimming of the chilled dressed beef for the various cuts.

**28. Horns and Horn Piths.**—Among the important by-products of the bullock are the horns. The constantly growing practice of dehorning has caused the supply to diminish from year to year, and good horns are becoming

scarcer each year. In spite of this fact, the value of horns has not been increased to any considerable extent, owing to the fact that manufacturers use celluloid and similar compositions as substitutes.

**29.** The horns on the cattle heads are sawed off close to the skull after slaughter. To separate the enclosed pith in the horn, it is merely necessary to cook the whole at 160° to 170° F. for 30 minutes. The hot water is then replaced by cold water, to cool the horns and make their handling easier. A heavy stroke of the horn on iron, or vice versa, will cause the pith to fly out. It is very important that horns should not be overcooked, as this will cause them to turn yellow and become brittle, thereby seriously damaging them. If, however, they are not sufficiently cooked, the pith cannot be removed, or at least not without great difficulty. In this case, the horns must be reheated in the water until the proper condition for the removal of the pith is obtained.

After the pith is separated from the horns, the latter are sorted into various grades—steer, cow, bull, stags, stumps, and useless horns. *Steer horns* are the most valuable, and have a smooth surface on the outside as well as on the inside. This is a convenient, practical test for distinguishing large cow horns from steer horns. The weight of steer horns is small considering the size of the horns, varying from 40 to 100 pounds per hundred pieces. They are classed as *No. 1 horns*. All steer horns averaging below 40 pounds per hundred, and cows, bulls, stags, and stumps are classed by the manufacturers as *No. 2 horns*. *Stump horns* are those of all grades from which the tip is absent or badly damaged. *Stag horns* are of a rough nature, weighing about 2 pounds each. Useless horns include all misshapen, overgrown, or irregular horns.

Horns will lose in drying about 12 per cent. of their original weight. They are stored in a cool place, to prevent them from becoming too brittle. Horns are used for the manufacture of imitation tortoise shell, for combs, buttons,

and similar articles, and for pipe-stem tips. The refuse horns, clippings, etc. are made into a fertilizer material called *hoof meal*, which will be described further on.

**30. Horn piths**, after being knocked from the horn, are stripped of the skin covering them and then dried on the floor at a moderate temperature. The cleaner this product is and the freer from bloody tips, the higher price it will bring. Horn piths are used extensively for the manufacture of edible gelatines, and also furnish the glue maker with an excellent raw material.

**31. Blood.**—The blood from the bleeding bullock is conducted to a reservoir, from which it is pumped to the cooking tank, or vat, in the fertilizer department. The liquid blood from the average beef is 40 pounds. The treatment of this product will be described later.

**32. Fertilizer Materials.**—All material from the slaughtered bullock not wanted or not suitable for other purposes may be classed as fertilizer material. It includes lungs, pecks (the third stomach of the bullock), spleen, and refuse from the manipulation in the packing house of the other by-products. Fertilizer materials also include all animals or parts of animals that are found on examination to be diseased or unfit for food (see Art. 9). This material, when rendered, furnishes tankage, tallow, and tank water, the latter being the cooking water heavily impregnated with nitrogenous compounds. Tank water is at the present time made into a fertilizing material by evaporation. This is known as *concentrated tankage*, or in the packing house as *stick*, the treatment of which will be described further on.

The foregoing products, as mentioned before, may be, and are, subdivided in many cases, but this subject is best treated under the different classes of products, where they are discussed more fully.

### HOG PRODUCTS

**33.** The dressed carcass of the hog is capable of many dispositions, which depend on many conditions, notably the locality for which it is destined. The various methods of transforming the dressed hog into the very numerous cuts, regulation and otherwise, is so complicated that personal observation and practice is far more valuable than description. The resolution and disposition of the offal is more complex than that of the bullock. The offal from the hog, speaking comparatively, is of more value than that of the bullock, as the finished by-products of the former are much more remunerative to the packer than those from beef.

**34.** The chart, Fig. 2, shows, approximately, the resolution of the hog into the most important packing-house products. The same is true here as with the chart of resolution of the bullock; that is, while showing the general result, many of the by-products may be still further divided when deemed profitable. All these by-products are not manufactured in every establishment, but in the largest packing houses, which are conducted on scientific principles with the aid of chemistry, these, together with many allied products, are manufactured daily in very large quantities. As many packing houses handle hogs only, the utilization of every product possible under the circumstances is a necessary factor in obtaining satisfactory financial results, the latter being the basis on which this, as well as every industry, is conducted. The disposition of the offal in the packing house will be described in detail.

The most important by-product, although not always considered as a by-product, is lard. The subject is so important and the treatment and manufacture so varied that it will be treated under a separate heading.

**35. Head.**—The head of the hog, after removal at the time of slaughter, is thoroughly washed in water so as to remove the blood and adhering dirt. Several dispositions are made of this product. In all cases, the tongue is removed







and treated by itself. If the heads are intended for sale purposes, they are scraped free from all hair and bristles, washed thoroughly clean in cold water, and chilled for 24 hours, when they are ready for sale. At times, they are split in halves and pickled in strong brine for 2 weeks, when they are packed in barrels for shipment, mostly to tropical countries. When intended for lard purposes, the heads, after being cleaned and washed, are sent to the rendering tank with other suitable material and cooked for lard.

Still another use for the heads is the manufacture of head-cheese in the sausage department. Here, they are cooked in open vats until the flesh loosens, when they are removed and the bones separated from the meat. This meat, together with the skin of the hog or similar glutinous matter for adhesive purposes, is made into a chopped mass with other materials, stuffed into cleaned hog stomachs, and then cooked in practically the same manner as sausages. This latter use is the most profitable for the packer, as by it he obtains lard from the cooking of the heads, the meat for a profitable use, and the bones for fertilizer.

**36. Blood.**—The blood from the slaughtered hog is conducted to a reservoir and treated the same as the blood from cattle, as will be described later.

**37. Food Products.**—From the hog, broadly speaking, food products include almost every part of the hog. With the exception of the gall, bones, and bristles, all parts may serve as edible products. Specifically, they will be treated here as the heart, liver, and leaf lard, the latter finding its most important use as neutral lard and as a component of oleomargarine, or butterine.

**38. Heart.**—The heart finds its most important use in the production of sausages. It is frequently sold attached to the liver and lungs by a short piece of the windpipe, the whole being technically termed the *pluck*. When not desired for these food purposes, it is sent to the tank and rendered for fat, the fleshy residue furnishing a fertilizer material rich in nitrogen.

**39. Liver.**—In the United States, the liver of hogs finds restricted use as food, but in many foreign countries this is its only utilization. The fresh livers, preserved in a solution of salt, borax, and boracic acid, were largely sent abroad from the large packing centers, arriving at their destination many days afterwards in a condition hardly distinguishable from the liver freshly removed from the hog. Of late years, however, this disposition has been greatly restricted, owing to the passage of stringent laws in many foreign countries against the importation of such meats packed with preservatives.

Hog's liver is very serviceable as a component of piquant table sauces, although its use is limited. The livers are also cooked, dried, and then ground into a powder and used as a component of dog biscuit. This outlet is a very important factor at times in disposing of a surplus. When not desired for other purposes, the livers are cooked under pressure, when they yield only tankage and tank water. The tankage from livers contains about 14 per cent. of ammonia when dried, and furnishes a readily and easily available source of nitrogen in fertilizers.

**40. Leaf Lard.**—Leaf lard when removed from the hog is chilled, as described later, when intended for the making of neutral lard. For sale purposes, it is hung from the middle of the piece, on slanting pegs about 6 inches long, and allowed to chill in this condition. When removed, with the skin side exposed, it presents a smooth, cone-like, homogeneous lump.

**41. Feet.**—The feet after removal from the dressed hog, which has been chilled for about 48 hours, are sometimes sold in the fresh state, after being thoroughly cleaned and freed from all hair and the horny toes. These toes, after being cooked under pressure to loosen the tissue so that they may be easily ground, are sent to the fertilizer tank. They furnish a fertilizing material containing about 19 per cent. of ammonia. This material is generally mixed with the ordinary tankage from hog offal to raise the grade in

ammonia. The small projections on the back part of the feet, called the *haws*, corresponding to the dew claws on cattle, also have their horny covering removed, the material likewise furnishing fertilizer stock. The feet are also cleaned and cooked for 2 hours, after which they are split and placed in packages with vinegar and spices. For this purpose, the feet are first subjected to pickling in a solution of salt and water for 2 or 3 weeks. They are sold as pickled pigs' feet.

When not desired for food purposes, the feet are cooked under pressure for lard and tannage. The lard obtained in this manner is of a very oily nature, consisting of a large per cent. of olein and very little stearin. It may be mixed in cool weather with ordinary lard, when its oily characteristics are not apparent. Pig's-foot lard furnishes, on pressing into oil and stearin, a very large yield of lard oil, and is very frequently utilized for this purpose. The yield of lard from feet is about 16 per cent. The most profitable use of pigs' feet for commercial products is for glue, which product is largely made in the Chicago packing houses. The front feet of the hog are usually employed for making pickled pigs' feet, while the hind feet are used for glue material and lard.

**42. Kidneys.**—The kidneys are always removed from the slaughtered hog, thus differing in disposition from the beef kidneys. The latter are always left with the dressed carcass, embedded in the kidney fat. Hog kidneys find extensive sale in the fresh state, whatever surplus there may be going to the rendering tank.

**43. Hair and Bristles.**—The hair and bristles of the hog furnish by-products of extensive utility. As the slaughtered hog emerges from the scalding tub, the bristles are selected from along the ridge of the back and the hams. They are chosen as to length and color, the black, brown, and white being kept separate. The hair and bristles are almost always sold by the packer to contracting firms at a certain price per hog, the season of the year, by virtue of the condition of the hair and bristles, largely influencing

this value. The contractor always takes care of the product, furnishing all labor required for selecting, removing, curing, etc. The hair and bristles are spread in fields to dry, when they are packed with salt and brine in barrels and bags and sent to the brush manufacturers. Hair that is not suitable for this purpose is sold and made into a cheap grade of curled hair, which is used by mattress manufacturers, and also for padding horse collars, cushions, etc.

Owing to the high percentage of nitrogen in hair, recent developments are toward the utilization of the cheap and ordinary hair for the production of the nitrates, in a soluble or available form, by dissolving it with acids or other suitable agents.

**44. Manufactured Goods (Food Containers).—**The same may be said of manufactured goods of pork as was said of those of beef. From the hog, they include sausage casings and bladders. The bladders are prepared by voiding and then soaking in cold water and brine for a day, when they are trimmed free from fat, distended with air to their fullest extent, and dried at a temperature of 140° F. for 24 hours. They are then ready for use after expelling the air and folding lengthwise. The rough end, where they are tied to retain the air, is cut off before packing for shipment.

Bladders of hogs find extensive use abroad for packing lard for sale purposes. They are sometimes colored and used for carnival purposes. In former years, bladders were largely employed for packing snuff. When parchmented by means of dilute sulphuric acid, they are used for the covering of glass-stoppered jars and bottles.

**45. Casings.—**Hog casings are classed as *hog casings* and *hog bungs*, the latter being the last 4 feet, or thereabouts, of the intestines. These, again, are graded according to length and condition. They are thoroughly cleansed inside and out and salted to preserve them, as is done with the beef casings. There is a marked distinction between the texture and appearance of the hog bung and the beef bung. The former is of a close, compact, and solid texture, with a

white, opaque appearance. The beef bung is of a fibrous, heavily veined structure, and is of a yellowish, transparent or translucent appearance. The hog bung is almost universally employed for liver sausages, while that of the bullock is used for bologna sausages.

Hog casings are made from the small intestines of the hog. The preparation of these differs from the manner of preparing the corresponding beef intestines. They are allowed to ferment for a day in warm brine, to loosen the attached mucous coating. This fermentation has been found by experience to be a necessary procedure for thoroughly and, at the same time, more easily removing the mucous membrane and accompanying slime. Another day's soaking in moderately cold water prepares them for cleaning, which, in small establishments, is done by hand; in large ones, by machinery. The treatment of the intestines after cleaning is carried out the same as that of the beef casings, as has been described. This intestine of the hog varies in length from 40 to 75 feet, and, unlike that of the beef, is not fat nor embedded in fat, but simply attached to it. The yield of casings per hog is about  $\frac{1}{4}$  pound, and the use is for high-grade sausages. The refuse and useless intestines are tanked under pressure for fertilizer material (see Art. 9).

**46. Stomach.**—The stomach of the hog when voided, scraped, and cleaned furnishes an envelope for filling with sausage material, such as headcheese. After cleaning, the stomachs are preserved in a strong solution of salt and water until wanted for use.

The stomachs are also the source of a most important product—*pepsin*. Most packing houses do not make this finished product, but prepare the stomachs by cleaning them thoroughly and shipping them to the pepsin manufacturer in a solution of borax and boracic acid. When stomachs are not used for the purposes just mentioned, they are cooked under pressure for fertilizer material, furnishing tankage similar to tripe from bullocks.

**47. Pancreas.**—The pancreas, or sweetbread, furnishes the digestive ferment *pancreatin*. This product is made only by some of the largest packers. In establishments of moderate size, the pancreas is usually tanked with fertilizer material.

**48. Fat.**—The fat of the hog suitable for lard material is cooked for the production of lard of various kinds. All fresh and clean fat of the hog in sound condition is suitable for this purpose. All fatty refuse material not suitable for lard is cooked under pressure, producing grease and fertilizer material. Such material is found in the refuse from cleaning intestines, in catch basins, etc.

**49. Fertilizer Material.**—The fertilizer material of the hog consists of all material that is not wanted or is not suitable for food or other purposes. Products that have become unsalable or have deteriorated are also made into this material and the accompanying grease recovered. During the operation of dressing the slaughtered hog, many parts become so soiled as to be unsuitable for meat or lard, and these, together with all meaty and fatty material, are sent to the fertilizer tank. Clotted blood, the spleen, rejected intestines, etc. also furnish this material

Hogs condemned by meat inspectors, on account of disease or unsuitable condition at the time of slaughter, are also sent, viscera and all, to the fertilizer tank and rendered into grease and tankage. The water in which all meaty or nitrogenous animal matter is cooked under pressure is known as *tank water*, with the characteristics previously described.

The products of the hog mentioned are the principal primary ones. As with beef products, these may be still further resolved, as, for example, lard and grease into lard oils and stearins. This subject will be treated later.

### CALF PRODUCTS

**50.** When possible, calf products are disposed of in a manner analogous to those of beef. But the by-products of the calf are very limited, as about two-thirds of the live weight is disposed of as dressed meat. Calves are almost always sold with the skin, or hide, attached to the carcass.

The **viscera** and internal organs of the calf, together with the legs and head, form the by-products. From the **entrails** and **fat** are produced a small quantity of tallow and tankage. No sausage casings are made from the entrails of calves, as their tender condition renders them entirely unsuitable for handling.

The **feet** yield a small quantity of neatsfoot oil, and when utilized for glue furnish a rich material for gelatine. A very limited sale occurs at times for the cleaned feet in the fresh state, for edible purposes.

The **heads** are sometimes cleaned, scalded, and prepared for food purposes. Where this is not done, they are tanked with the fertilizer material. They also furnish a serviceable glue liquor.

The **tongue** is always removed from the head, and is either sold in the fresh state or cured and sent to the canning department.

Calf **sweetbreads** always find a ready sale as a table delicacy and bring very high prices. The **brains** are frequently removed from the heads and also sold as delicacies.

The **blood** and worthless offal are made into the usual fertilizers.

The **heart**, **liver**, and **lungs** attached to a piece of the windpipe, together known as the pluck, are always sold in the fresh state for food purposes.

**Unborn calves**, known technically as *slunks*, are skinned when the hide is covered with hair. The rest is made into fertilizer.



### SHEEP PRODUCTS

**51.** In slaughtering sheep, the usual method is first to cut the animal's throat, severing the jugular vein, and then to break its neck by bending its head back sharply. After the slaughtered sheep is dressed, the warm abdominal fat—the thin, apron-like sheet known as the *caul*—is wrapped around the carcass, encircling the hind quarters as much as possible. The kidneys attached to the body are pulled through a slit made in the warm fat, and the carcass allowed to chill in this condition.

**52.** The offal of sheep is not so diversified as that of the hog or bullock, and is not subdivided to any considerable extent.

The **intestines** are all utilized in the manufacture of sausage casings, in the same manner as those of the hog and the bullock.

The **hearts** are used for the making of sausages, a large number, however, being sold in the fresh state.

The **livers** formerly found a large sale as "calf" livers. They are now sold under their proper designation. A distinguishing characteristic most frequently present in sheep liver is the occurrence of hard lumps, or cysts, scattered throughout the organ. These are never present in the liver of the calf. The livers that cannot be sold in the fresh state are tanked for fertilizer.

The **lungs** are always tanked for fertilizer, when not sold as sheep pluck, this being the heart, liver, and lungs attached to a piece of the windpipe.

The **heads** are either tanked under pressure or boiled in open vats for the production of mutton tallow, when in quantity. In the latter case, the residue remaining in the vats is further cooked in the pressure tanks, as a considerable quantity of tallow always remains in the material after this mild cooking. The heads are otherwise cooked with the rest of the fertilizer material of the establishment for tallow and tankage.

The **tongues** are always removed from the head, and find their outlet as pickled lambs' tongues. Frequently, they are canned under the same name.

The **feet** when cooked by themselves yield a dark-red oil, analogous to No. 1 neatsfoot oil. A test made on sheep feet for oil and tankage gave 4.54 per cent. of oil and 24 per cent. of dry tankage of low grade. Unless a large quantity of material of this nature is always on hand, the feet are cooked with other fertilizer material.

**Lamb fries** is the trade name given to the testicles of sheep. They are sold in the fresh state under this name.

The **paunches**, emptied of manure, are utilized for fertilizer material, as is also all other offal not otherwise used.

The **pelts** of sheep, with the exception of very young lambs, known as *spring lambs*, are removed after slaughter. These are either disposed of fresh or made into packs with salt sprinkled between each skin for the purpose of curing them. In the largest packing houses, the wool is pulled from the pelt in a department known as the *wool-pulling house*. Here the pelts are treated with a depilatory, which, after a period, loosens the wool from the skin and allows of easy removal. In far the greater number of establishments, however, the pelts are sold as before mentioned.

**Spring lambs** are always sold with the pluck attached to the carcass and with the skin, or pelt, also left on.

**Unborn lambs**, if provided with wool, are skinned, and the remainder is cooked for fertilizer. The skin of unborn lambs furnishes a most excellent material for the manufacture of parchment or vellum.

The **tallow** obtained from sheep product is described further on.

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## GOATS

**53.** The slaughtering of goats is carried out in the same manner as that of sheep, as is also the dressing of the carcass. Their by-products, so far as possible, are handled like those of sheep. While in the aggregate a great many goats are annually slaughtered for food, their number is not as yet of

sufficient importance in any one establishment to classify their by-products under their own nomenclature. The carcasses of goats, dressed like sheep, were formerly sold in the trade as mutton.

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### MEAT

**54.** By referring to the charts, Figs. 1 and 2, it will be observed that the broad divisions in the packing industry of both hogs and cattle are dressed meat and offal. As the latter term includes, at the same time, meat as well as other things, it is timely to designate what is meant by the term *meat*. The (German) Imperial Health Office, in a pamphlet issued in the year 1899, covers this definition most comprehensively and also gives therein some analyses of the different kinds of edible meats. The following paragraphs are translated from this document.

**55. Definition of Meat.**—The word *meat*, in the broadest sense, means all eatable parts of all kinds of animals. In its proper sense, it refers to muscular meat, and in commercial life, it means muscular meat connected with the corresponding bones, muscular and fat tissues, and glands. As meat is also taken, it includes the tongue, the heart, the lungs, the liver, the milt, the kidneys, the brains, the mamillary glands, the stomach, the guts, the udder, certain parts of the skin, especially from the head and from the legs, and also fat and blood. It further comprises all products from edible parts of animals (meat and fat products) and preparations, like ham, bacon, canned meat, sausages, gelatine, meat meal, meat extract, salted, corned, smoked, cooked meat (boiled, roasted, steamed, broiled), dried parts of meat, and melted fats, like lard and oleomargarine.

**56. Meat as Food.**—Meat is one of the most important foods for man. It contains all nutritious matter necessary for the building up of the body, in useful composition and comparatively easily digestible form. The composition and digestibility, and consequently the food value of the meat, however, differs with different kinds of animals, and varies

with the age and sex and the food used for the animals. Good average percentages from a large number of analyses are given in Table I.

**TABLE I**  
**ANALYSIS OF VARIOUS MEATS**

Meat	Water	Nitrogen	Fat.	Ash
Very fat ox meat . .	53.05	16.75	29.28	0.92
Medium fat ox meat .	72.03	20.96	5.41	1.14
Lean ox meat . . .	76.37	20.71	1.74	1.18
Fat cow meat . . .	70.96	19.86	7.70	1.07
Lean cow meat . . .	76.35	20.54	1.78	1.32
Fat veal . . . . .	72.31	18.88	7.41	1.33
Lean veal . . . . .	78.84	19.86	0.82	0.50
Very fat mutton . .	53.31	16.62	28.61	0.93
Medium fat mutton .	75.99	17.11	5.77	1.33
Fat pork . . . . .	47.40	14.54	37.34	0.72
Lean pork . . . . .	72.57	20.25	6.81	1.10
Horse meat . . . .	74.27	21.71	2.55	1.01

The quality of the meat is further different in one and the same animal, according to the different parts of the body. The best meat, as a rule, is at the hind quarters; the poorest at the legs. The differences are not alone in the taste and digestibility, but also in the nutritious value, and it is therefore justifiable when, especially in large cities, different prices are asked and paid for meats from the different parts.

57. The United States Department of Agriculture has recently carried out investigations on many food products, determining the value of food for nutriment, digestibility, etc. Nearly 5,000 analyses of different foods from all parts of the country have been made during the last few years, and some of these applicable to packing-house products are given in Table II.

It will be noticed that *protein* is stated instead of nitrogen percentage. The protein figures are obtained from the

TABLE II  
AVERAGE COMPOSITION OF CERTAIN PACKING-HOUSE FOOD PRODUCTS

Food Materials (as Purchased)	Refuse Per Cent.	Water Per Cent.	Protein Per Cent.	Fat Per Cent.	Carbo- hydrates Per Cent.	Ash Per Cent.
<i>Beef, fresh:</i>						
Chuck ribs . . . . .	16.3	52.6	15.5	15.0		.8
Flank . . . . .	10.2	54.0	17.0	19.0		.7
Loin . . . . .	13.3	52.5	16.1	17.5		.9
Porterhouse steak . . . . .	12.7	52.4	19.1	17.9		.8
Sirloin steak . . . . .	12.8	54.0	16.5	16.1		.9
Neck . . . . .	27.6	45.9	14.5	11.9		.7
Ribs . . . . .	20.8	43.8	13.9	21.2		.7
Rib rolls . . . . .		63.9	19.3	16.7		.9
Round . . . . .	7.2	60.7	19.0	12.8		1.0
Rump . . . . .	20.7	45.0	13.8	20.2		.7
Shank, fore . . . . .	36.9	42.9	12.8	7.3		.6
Shoulder and clod . . . . .	16.4	56.8	16.4	9.8		.9
Fore quarter . . . . .	18.7	49.1	14.5	17.5		.7
Hind quarter . . . . .	15.7	50.4	15.4	18.3		.7
<i>Beef, corned, canned, pickled, and dried:</i>						
Corned beef . . . . .	8.4	49.2	14.3	23.8		4.6
Tongue, pickled . . . . .	6.0	58.9	11.9	19.2		4.3
Dried, salted, and smoked . . . . .	4.7	53.7	26.4	6.9		8.9
Canned boiled beef . . . . .		51.8	25.5	22.5		1.3
Canned corned beef . . . . .		51.8	26.3	18.7		4.0

[illegible]

nitrogen found by multiplying the percentage of nitrogen by the factor 6.25. It may be stated that the methods of chemical analyses of foods are now so nearly uniform throughout the world that the analyses reported from different countries furnish a reliable means of comparing the composition of the food products of different parts of the world.

### PROCESSES FOR THE MANUFACTURE OF LARD

58. Lard is the rendered fat of the hog. The several grades of lard produced by the packing houses are made by

quite different processes, and the care of operating depends on the grade of lard, although careful attention to details is always of the utmost importance.

The cheapest grade is *steam-rendered lard*; that is, the lard extracted from the stock by the direct contact of steam under pressure. *Kettle-rendered lard* is lard extracted in kettles heated externally, and is the highest grade of household lard. *Neutral lard* is made by a more complex process.

The importance and value of this

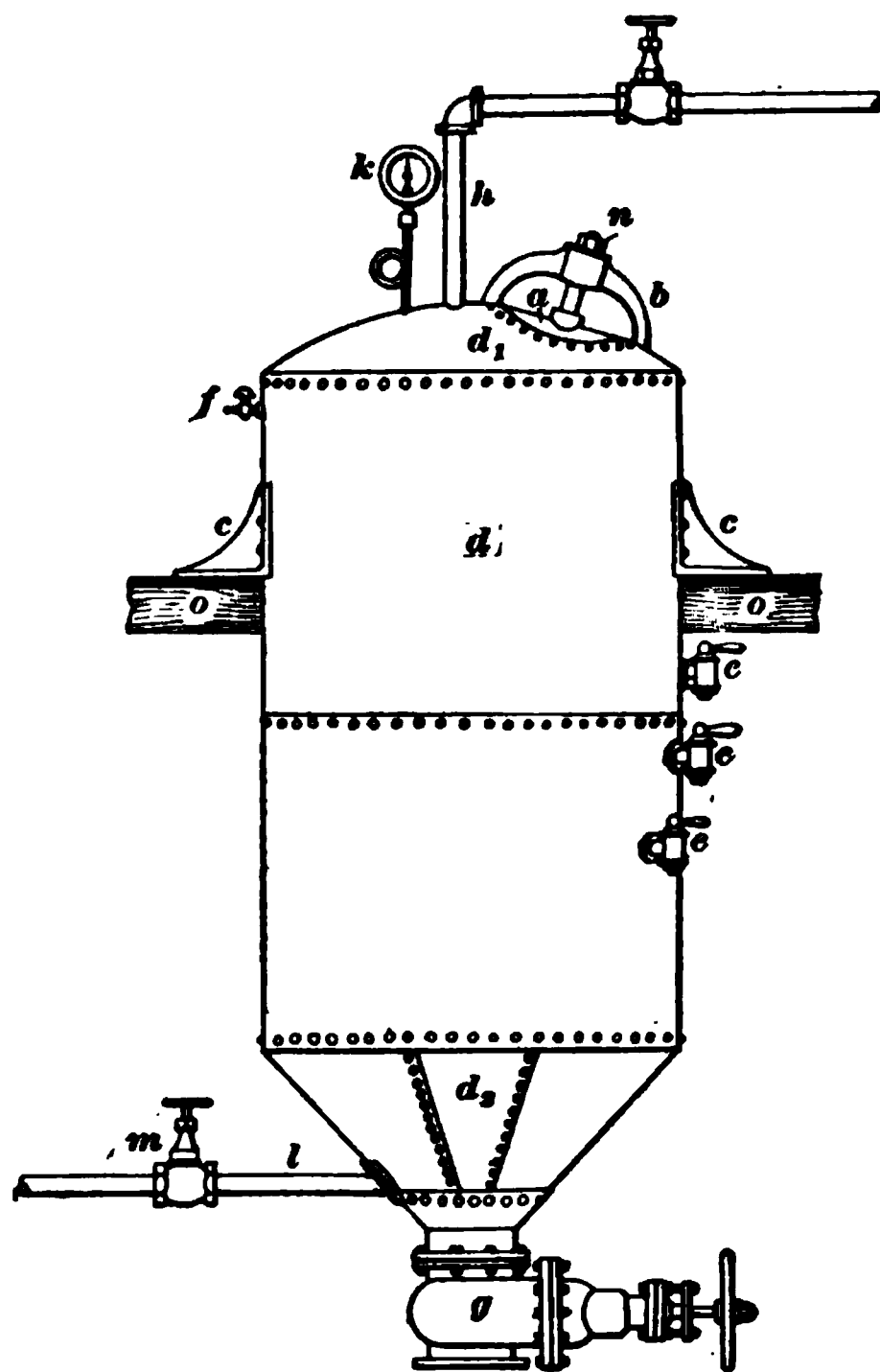


FIG. 3

product are so great, constituting as it does the largest by-product of the hog-killing branch of the business, that the

methods of production will be given in detail. Many small points, while seemingly of little moment, are of the utmost importance in the treatment of this material. The production of a high-grade article by proper cooking and handling is not only economical and advantageous, but it also obviates the too frequently applied after-treatment necessary to make a marketable lard.

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#### STEAM-RENDERED LARD

**59. Rendering Tank.**—A modern rendering tank is shown in Fig 3. The body *d*, the top *d*<sub>1</sub>, and the conical bottom *d*<sub>2</sub> are made of steel or iron, riveted. The head *a* of the manhole is held in place by the clamp *b* and nut *n*. The pipe *h* is the exhaust leading to the condenser. The steam gauge *k* indicates the pressure in the tank. Steam is admitted to the tank through the pipe *l*, the pressure being controlled by the valve *m*. The valves *e* are for drawing off the lard. The petcock *f* is for the escape of gases during cooking. The gate valve *g* is for the removal of cooked meat, etc.

This tank is a marked improvement over the old-style tank, which is constructed with cone top and cone bottom. The apex of the bottom cone in such a tank, being always below the lowest of any draw-off cock, or valve, forms a receptacle in which the foul drainings from previous renderings collect, and is a most fruitful source of discolored lard or other material, unless great precautions are taken to remove this condensed liquid completely. In the modern construction, this great disadvantage is overcome, as may be readily seen. There are, however, a great many cone-bottomed tanks in use today in packing houses, but they are being replaced constantly by tanks of the newer style.

Many of the old-style rendering tanks have in them, at the top of the cone, or rounded bottom, false bottoms of perforated iron. The object of such a bottom is to keep the raw material from packing below the entry point of the steam, where it would escape cooking to a great extent. Another



point with the false bottom is that it allows the water to percolate through it, retaining the solid material on top and level with the door, or *gate*, which, in this style tank is about 15 inches square in the body of the cylindrical part of the tank. Through this gate the solid cooked material is withdrawn by means of long, bent forks. Naturally, there is considerable labor attached to this operation, which in the modern tank without a false bottom is entirely eliminated. The whole contents of the cooked tank is completely removed in a very few minutes by simply opening the large bottom valve *g*. This saving of time and labor during the busy seasons in the packing houses is of great importance. Under the old system, serious delays were frequent, due to the tanks not being cleansed and made ready for fresh material.

60. The rendering tank is usually from 5 to 6 feet in diameter and from 14 to 16 feet high. The modern tanks are made of steel instead of iron, and the cylindrical shell is made of two rings. The idea of modern construction is to have as few seams as possible in the whole tank, and to have the inside laps of the circular rings so arranged that they point down rather than up. In this way the material that in a short time generates fatty acids that will rapidly corrode the seams is prevented from lodging on the edge of each ring.

A suitable combination of wood made impermeable to moisture or some other material should be on the charging floor surrounding every tank, as by this means drippings of water and washings from the floor will be prevented from running down the sides of the tank.

In the old-style tanks, the bottom rested on a timber framework; this proved objectionable from the fact that it prevented access to the bottom plates and at the same time encouraged corrosion by keeping a wet surface constantly in contact with the iron. In modern construction, the tank is suspended entirely free from the floors *o*, Fig. 3, except where supported on the lugs *c*. By this method, the external surface of the tank is always visible for inspection and kept free from corrosion.

**61. Precautions for Safety of Tanks.**—Rendering tanks in large cities are subject to the same regulations regarding inspection as steam boilers. Even where municipal inspection is not obligatory, the packers have the tanks periodically tested and inspected. If the slightest flaw or weakness is detected, the tank is immediately put out of service until made thoroughly safe.

The rendering tank is of such importance in the packing and rendering industries that the greatest care is taken in its construction. The life of the ordinary rendering tank is, to a great extent, dependent on the class of material cooked in it and the care it receives in handling. With good usage, the average tank will last about 20 years.

**62. Operation of Steam Rendering for the Production of Prime Steam Lard.**—The rendering tank must be thoroughly clean on the inside. When a new rendering tank is first put into service, it is always used for cooking grease material in order to remove all rust, oil, dirt, and other extraneous matter incidental to its making. If this plan is not followed, the lard coming from the new tank will always be more or less dark and discolored and most likely will have an "off" flavor. This method of cleaning a new tank is always followed in the packing houses.

Where the cone-bottom tank is used, great care should be taken to remove all the old tank water or other material from the apex of the cone. Clear water is run into the tank until it is about one-quarter full. The material is then dumped in, care being taken, however, that the fat does not pack where it strikes inside the tank. Packing is a prolific cause of *cold spots*, and consequently of sour lard, and may be avoided by distributing the material evenly over the interior of the tank with a long pole.

The stock in the tank is thus washed while being *loaded*, as the filling is technically termed. To further this washing, a stream of cold water from a hose at the top of the tank is kept running over the material, and, at the same time, in order to maintain the same level of water on the material, an equal

amount of water is allowed to escape at the bottom. A great deal of blood from the material is in this way eliminated. The more washing lard material receives prior to the cooking, the better will be the quality and color of the lard produced.

When the tank is about three-fourths full of stock ready for cooking, the flow of water is stopped both at the top and the bottom, and the head is put into the tank. This head, similar in shape to a manhole cover, is screwed down tight with a wrench that should not be longer than 18 inches. When the joint cannot be made tight with that leverage, the head should be removed and refitted with better packing. To force the head on with a longer leverage frequently results in a fracture of the mouthpiece or frame, and when steam is turned on in such a case, the tank is liable to burst and cause loss of life and property.

**63.** The tank having been properly closed, steam is now turned on. The steam is allowed to enter the tank under full pressure, which is generally from 40 to 50 pounds. The safety valve is now tested to ascertain its free working. This valve should be so regulated that it will blow at the maximum pressure used for cooking the material. The exhaust pipe on the top of the tank is kept wide open until the pressure gauge shows a pressure of a few pounds, when it is almost, but not wholly, closed, to allow the steam pressure to rise to the maximum pressure.

The petcock *f*, Fig. 3, at the top of the tank is always kept open while cooking, to allow the gases generated by the cooking material to escape. These gases are a mixture of hydrocarbons and sulpho-gases, of which hydrogen sulphide forms a large part. These gases, if confined while cooking the lard, would so impregnate it that the lard produced would be of strong and gassy flavor and unsalable as first-class product or standard lard in the trade.

**64.** When the steam-pressure gauge shows a pressure of 35 pounds, the steam supply is partly shut off, so that the incoming steam is balanced by that escaping from the petcock

and the now partly closed exhaust pipe. In this way, the steady pressure desired for cooking is maintained. It is very essential in cooking lard that a steady pressure be held with the steam, as in this way a uniform product can always be obtained.

From 15,000 to 20,000 pounds of lard material, which will fill the average packing-house tank three-quarters full, should be allowed to cook at a pressure of 35 pounds for about 11 hours, the time being reckoned from the time that this pressure is obtained. With the tank only half or quarter full of stock to be cooked, a reduction of time of cooking and also of pressure must be made. Thus, with the tank quarter full, a pressure of 25 pounds for 9 hours will be sufficient, while with the tank half full a cooking of 10 hours with a pressure of 30 pounds will serve the purpose. The pressure employed, as well as the time of cooking, varies in individual packing houses, according to preferences and experience. For example, some prefer to render lard at a pressure of 40 pounds for 9 hours, which, in some cases, gives equally as good results.

**65.** The object of cooking raw lard material is to break the membranous cells enclosing the fatty material, to allow the oily material to escape from its coverings, and to cook thoroughly the fleshy portions, so that what little of this remains in the rendered lard is, in a large measure, prevented from decomposing. Incipient putrefaction of the raw material is thus prevented; hence, the great importance of rendering all material in as fresh a state as possible.

One of the most vital points in making lard is to start with the material in the proper condition, that is, as clean as possible. This applies more forcibly to the lard material from the killing of hogs than to the cuttings from chilled hogs that are made into the customary cuts of hog product for the trade. The stock from freshly slaughtered hogs should be washed thoroughly so as to free it from blood and natural filth. If this is not done, the rendered lard will have a dark, brownish color and a disagreeable, strong, pungent

odor. Such lard will not pass the usual inspection required for the sale of lard or the requirements of the various boards of trade or chambers of commerce. (See Art. 97.)

**66.** During the progress of cooking, the operator examines the outside surface of the tank by feeling, to ascertain whether or not the material inside is being heated equally. Should any part of the tank be cold, it shows that the stock is packed solid in that part and that the steam is merely cutting a channel for escape through it. This is technically known as a *cold spot*, and, unless remedied, gives rise to sour or putrid lard. The remedy consists in immediately shutting off the live steam and allowing the tank contents to settle for a short time. Then, from the valve in the back part of the tank, the water is drawn off until the lard appears. The valve is then closed and the steam again allowed to enter with full force. This procedure breaks up the compactness of the mass and disintegrates the material so that the steam then acts on each piece. The pressure is then regulated in the manner already described.

It frequently happens that more material is placed in the tank for cooking than should be. In this case, while cooking, the tank becomes *flushed*; that is, the partly rendered lard with the steam and water is blown through both the petcock and the exhaust pipe, causing a serious loss of lard. This trouble can be remedied by shutting off the steam and drawing off from the tank, by means of the back valve, sufficient partly cooked material and water to reduce the level of the contents of the tank below the point where the lard is blown out. The back valve is then closed, the steam again applied, and the cooking proceeded with in the regular way.

The drawn-off, partly cooked lard is placed in the next tank of lard material to be cooked and the rendering of it completed. Flushing is a very common occurrence and is the cause of great losses in this branch of the business, especially in the busy and crowded season, when the tendency is to overload and crowd the tanks so as to take care of the large quantity of material.

**67.** After the cooking is completed, the steam is shut off and the petcock is opened wide, to allow the pressure to escape there as much as possible. At the same time, the exhaust is closed, as are also the escape valves. The object of this is to prevent the rolling of the contents of the tank, and the consequent forcible projection of the rendered lard through these openings. If there is no sign of rolling, the blow-off and escape valves are opened, a little at a time, observing carefully that the contents do not roll. If the rolling occurs, these valves are shut and a short waiting period allowed, until the cooked material has come to rest. After having blown off through the petcock about 30 minutes, the steam is allowed to escape as rapidly as possible, the safety valve being opened to assist in this operation. The object is to reduce the pressure in the tank as rapidly as possible, so that no lard will blow away with the steam.

After the pressure is gone, *and not before*, the head of the tank is loosened and allowed to hang in the manhole. The escape and blow-off, or exhaust, valves are then closed, to prevent any induced suction from drawing the condensed liquid (made by condensation of the gases) from the exhaust pipe back into the lard. This is a most frequent source of the discoloration of an otherwise perfect lard, and is a point to be carefully guarded against.

**68.** The rendered lard in the tank is allowed to rest for a period of several hours, to enable the fine, cooked fiber distributed throughout the lard to settle with the meaty material in the bottom of the tank. About 10 or 15 pounds of common salt is scattered on the surface of the lard, the object being to assist, mechanically, the fine scrap to settle. It also serves another purpose: The salt in passing through the lard comes in contact with the water, or moisture, still saturating it. A union of the water and salt immediately takes place and forms brine, which, being so much heavier than lard, immediately sinks through it, thus eliminating to a large extent the moisture in the lard. The sprinkling of the salt materially shortens the time required for the necessary

separation of the rendered lard from the water formed by the steam and the scrap and fine particles of meat scattered through it. The longer the time, within limits, allowed for settling, the better will be this separation and the better will be the quality of the lard when drawn from the tank.

**69.** When ready for drawing, or "tapping," the lard from the tank, the water underlying the hot lard is withdrawn through the valve in the back of the tank, near the bottom. This brings the lard down to the level of the valves *c*, Fig. 3, in the front of the tank. The level of the lard is lowered until, on withdrawing from the front valves, the lard issues from them clear and free from scrap, when the valve in the back is shut, and the clear lard run from the tank to the usual receptacle. After all the rendered lard has been withdrawn, the lower gate, or drop bottom, of the tank is opened, and the residue in the tank is allowed to run into the vat underneath the tank. The lard obtained by this process of cooking is **prime steam lard**, and constitutes the main output of lard from the packing house. The cooked material remaining in the vat is then prepared for fertilizer, the treatment of which will be described later.

**70.** After the contents of the tank is dropped into the vat, there is always more or less lard with it that rises to the surface of the tank water. It is not practicable, or even advisable, to draw off the rendered lard from the tank completely, as there is always danger of drawing off some of the tank water with it. Unless lard is completely free from tank water, it will very quickly become sour, or decomposed. As a matter of precaution, the flow of lard from the tanks is stopped when above the surface of the tank water inside, and what lard remains is allowed to mix with the tankage and tank water in the vat below, from which it is skimmed as it rises. This lard mixed with water and some scrap is technically known as *skimmings*. These are returned to another tank of lard material when about to be cooked.

**71.** Material from which prime steam lard is derived is made up of *killing lard* and *cutting lard*, so called in the

packing house. The former consists of the fresh, fatty material from the slaughtering, such as the heads, gut fat, ham facings, various trimmings, etc., and yields from 40 to 45 per cent. of prime steam lard when rendered. Cutting lard consists of the trimmings, back fat, etc. obtained from the chilled carcass when cutting into the various parts. This almost clear fat, when cooked for prime steam lard, will yield, from 70 to 75 per cent., depending, however, on various conditions.

From the average hog 8 pounds of lard is usually obtained from the killing fat and 22 pounds from the cutting fat, although the amount of back fat used with this material naturally influences the yield. The *grease* obtained from the average hog will be about  $\frac{1}{2}$  pound, or about 1 per cent. of the raw material.

**72. New Rendering Method.**—The apparatus employed in the usual methods of rendering in the packing house has seen little change in form or improvement until recently. The sanitary authorities were nearly always in conflict with the renderer, because the gaseous compounds unavoidably evolved in the rendering contaminated more or less the neighboring atmosphere. Within the last few years, a most excellent rendering system has been evolved that is destined in a very short period to supersede entirely the usual rendering apparatus in the small- and medium-sized plants, and in all probability, those in the largest packing houses. This system is known as the **Wannenwetsch combination sanitary rendering and drying system**, and is so immeasurably superior to the old-fashioned rendering apparatus that a detailed description will be given.

**73.** Fig. 4 illustrates a complete unit for rendering the fatty material, pressing the resulting tankage, or scrap, and drying the latter. This entire work is done in only one handling of the material, and all operations are carried out in the same apparatus.

The tank proper *a*, Fig. 4, is constructed very substantially, having heavy cast-iron heads in both the top and the



bottom, in distinction to the usual riveted sectional head in the ordinary tank. The lower part of the tank *b* is made jacketed for steam pressure. The tank is provided in the interior with an an agitator, which consists of a casting with

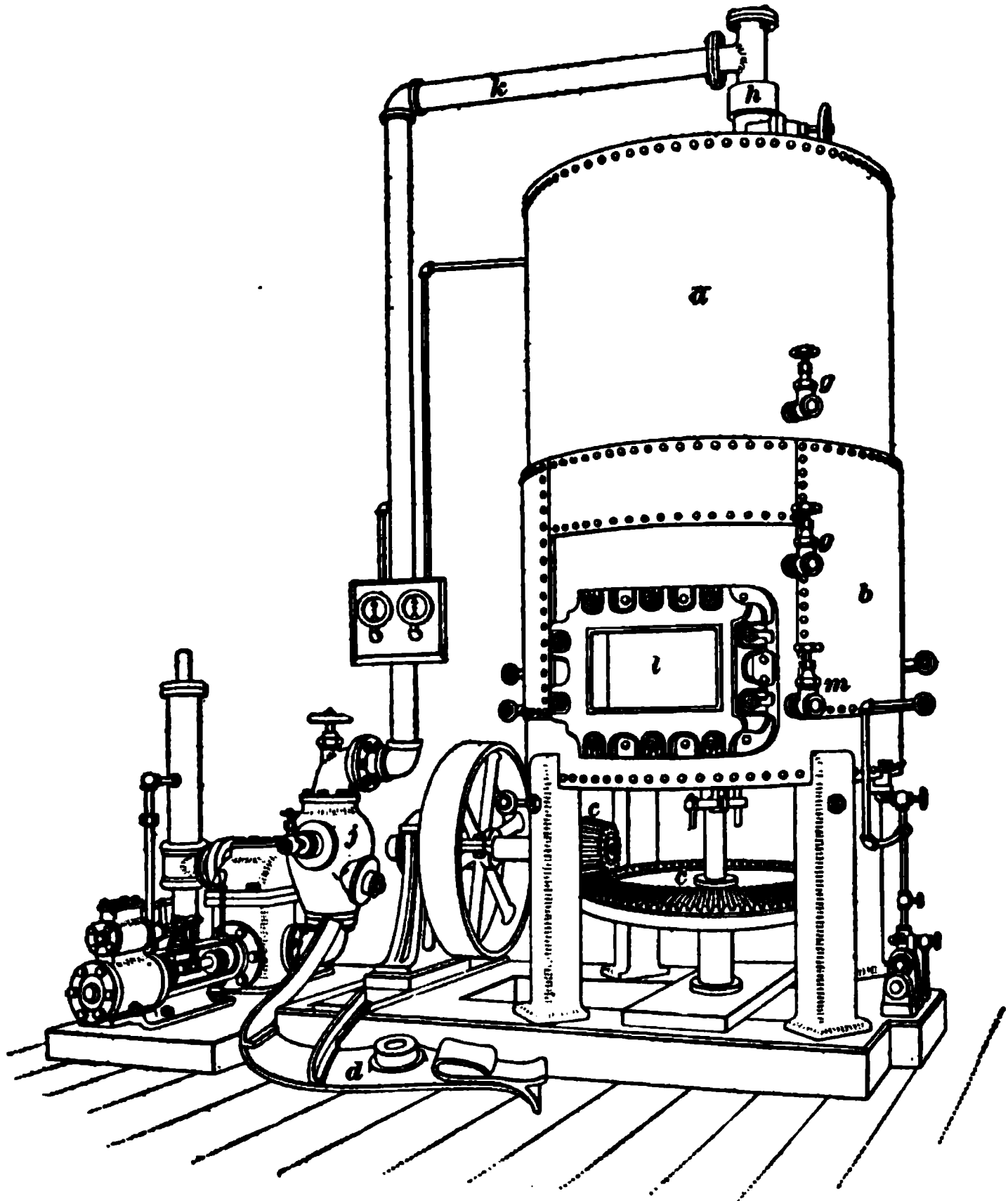


FIG. 4

blades that are actuated by the shaft and gearing *c*. A section of the agitator is shown at *d*.

**74. Operation of Wannenwetsch System.**—The material to be rendered is loaded in the usual manner,

through a door in the top of the tank. The door is then closed and made tight, and steam for rendering is admitted into the tank at a pressure of 40 pounds. The cooking is continued for from 2 to 4 hours, the time depending on the character and quantity of the material to be rendered.

The agitator inside the tank is now set in motion for about 15 minutes. This operation, together with the cooking, causes the destruction of the fat cells and disintegrates any bone present, thereby causing the fatty matter to be liberated. The cooking is continued for about 2 hours longer, when the agitator is again operated for further disintegration of the material.

The steam is now shut off, and the pressure is allowed to exhaust by means of a by-pass into the vapor line *k*, Fig. 4. The obnoxious gases (complex hydrocarbons, etc.; see Art. 63) always generated in rendering are drawn through a spray of cold water into the vacuum condensing chamber, the non-condensable gases being conveyed to a gas-collecting chamber, from which they are usually conducted to the furnace grates and burned. After all pressure is removed from the tank, the rendered lard, tallow, or grease is drawn off in the usual manner through the cocks *g, g* into settling tanks, or coolers.

**75.** After all fatty material is drawn off, all lard cocks are closed, the 4-inch valve *h* leading to the air pump *j* and jet condenser is opened, and the tank *a* is exhausted through the pipe *k* to a 25-inch vacuum. The residue in the tank, consisting of tankage and tank water, remains in the tank for drying, contrary to the usual operation of dumping the contents after rendering.

Steam is now turned into the jacketed lower part *b* of the tank, and the agitator is set in motion so as to prevent the material from baking or sticking to the heated surfaces and to assist the rapid evaporation of the moisture. By means of the testing valve *m*, the material may be examined from time to time, to ascertain its condition, without any interruption of the operation.

When the tankage has become sufficiently dry, the door *l* is opened, and, with the agitator still operating, the material is discharged by its action in the condition of ground tankage. When ready for the next charge, the door *l* is again sealed, the agitator and the air pump stopped, and the steam to the jacket of the tank shut off.

**76. Advantages of New System.**—By means of this unique system, the ordinary operations in the usual method of rendering and the separate pressing and drying of the tankage are eliminated, together with the expensive tankage presses and driers. The heavy labor and expense always attached to these operations are saved, and, in addition, tankage analyzing much higher in ammonia is obtained, owing to the tank water drying with the tankage at a low temperature. An increased yield of fatty material is obtained through the mechanical agitation while cooking, and consequently much less grease or fat is left with the tankage. The low operating expense and the wide adaptability of this system for rendering all classes of material, together with its obvious sanitary features, promise to replace rapidly the ordinary system of rendering offal.

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#### REFINED LARD

**77.** The lard next in importance in the packing house is **refined lard**, which is made from the regular steam lard. Although some years ago the term refined lard referred to mixtures of lard with tallow, cottonseed oil, etc., at the present time in the trade it refers exclusively to the pure and refined steam lard. The process of refining is of a very delicate nature, and outside of the packing house is unknown in all its details. This process, so important in this industry, will be described in detail.

By referring to Fig. 5, the method of operating may be followed. The iron tank *A* is provided with a cone bottom. The lard in the tank is heated by  $\frac{3}{4}$ -inch galvanized-iron pipes *c* running around the sides of the tank, the temper-









ature being governed by the steam valve *v*. The blower pipe *x* extends from the blower, or air compressor, *Y* to the bottom of the tank cone, terminating in a circle about 2 feet in diameter. The blower pipe from the top of the tank is 2 inches in diameter. The circle of pipe in the bottom of the tank is perforated with  $\frac{1}{4}$ -inch holes on the top, sides, and capped end for the purpose of distributing the air evenly throughout the lard, thereby agitating it violently when blowing. The cock *m* serves to remove water and settlings from the lard, and is consequently a very convenient aid in cleaning the tank.

The siphon *d*, held by the chain *k*, is attached to the feedpipe *e* by a swivel joint inside the tank. The siphon may thus be raised and lowered at will, the lower position representing it when pumping the last portions of material from the bleaching tank. The pump *F* withdraws the lard through the pipe *e* on opening the cock *o* and forces it into the filter press *R*, from which the bleached lard emerges and runs through the 2-inch pipe *j* into the agitator *H* for cooling, chilling, and drawing into the requisite packages.

78. With the apparatus just described, the operation of bleaching the lard is conducted as follows: The lard is pumped into the tank *A* through the pipe *b* until within about 2 feet of the top. As the lard for this purpose is usually taken directly from the rendering tank, it always contains more or less moisture. The lard is heated to 170° F. and the air blower turned on the lard. This is continued for 15 or 20 minutes, when the moisture will be driven off. If the lard contains much moisture, a longer time will be required to drive it off. The practical test applied to ascertain the presence or absence of moisture is to fill an ordinary 4-ounce, oil-sample bottle with the hot lard and allow it to cool for a few minutes. If moisture is present, the lard will become very cloudy and appear thick; if absent, the clear, hot lard will remain clear for a long period. If the hot lard does not cloud in the bottle within 2 or 3 minutes, no moisture is present.



**79. Bleaching With Fullers' Earth.**—The bleaching medium is now added to the hot lard. This, in packing houses, is always *fullers' earth*. The best temperature for bleaching lard is from 150° to 165° F., depending on the class of material under treatment. The quantity of fullers' earth, or "clay," varies in the same way, from  $\frac{1}{2}$  to 3 per cent. being the usual amount necessary to accomplish the bleach. Lard of good grade will require approximately  $1\frac{1}{2}$  per cent. to make it snow white.

The necessary percentage of fullers' earth having been added while the lard is agitated, the pump is started a few minutes afterwards, the fullers' earth in the interval acting on the lard in absorbing the coloring matter. The lard and clay are pumped into the filter press, the first runnings therefrom being returned to the bleaching tank, as they are usually not quite free from the fine fullers' earth. Until the filter-press cloths become filled and coated with the earth, the lard should be returned to the bleaching tank. The three-way cock *g*, Fig. 5, attached to the filter-press trough readily allows of this return by running from it through a movable pipe back to the tank.

The thoroughness of the bleach is determined by holding, in a water-white glass, the bleached lard to the light, when the natural yellowish tinge of lard is apparent. When the lard and the glass are of the same color, the bleach is perfected, no tinge of color appearing. The lard is then turned through the pipe *j* into the cooler and agitator *H*, where it is stirred and agitated mechanically until cooled to a thick, creamy consistency, so that it is barely able to flow or be drawn off through cocks or faucets.

**80.** The longer, within limits, and the more the bleached lard is agitated, the whiter is its appearance in the drawn-off packages. The agitation continues until all the lard has been withdrawn from the agitator. After all the lard has been pumped from the bleaching tank, the air blower is shut off from the tank and turned on to the filter press, so as to remove the lard held between the plates of the press.

The air pressure forces out the lard, which is added to that already in the agitator. To obtain what lard is held by the fullers' earth on the filter-press cloths, the air is shut off from the press and steam is forced through the whole press. The lard issuing from the filter press under these conditions must not be allowed to mix with good lard; it is usually sent to the grease tank. The steam is continued on the press until all grease matter has been steamed out. The air now replaces the steam, and the blowing is continued until the cloths and press are dry. After removing the fullers' earth from the cloths by scraping or shaking, the press is again ready for filtering. The cloths used for filtering are closely woven, strong drilling that is capable of withstanding great pressure. They are usually furnished by the filter-press manufacturers.

**81.** The most important points in bleaching are the complete absence of all moisture and the proper high temperature—about 165° F. The former condition, however, must prevail, or there cannot be a bleach. When fullers' earth is added to moist lards or oils, it immediately assumes a pasty condition, and when pumped with the lard into the filter press, it very quickly clogs the filter cloth with the pasty clay, rendering it absolutely air-tight. When this condition occurs, the whole operation, from the blowing of the material, must be started again, to eliminate the moisture; but, at best, it is a precarious condition, as too long a contact between the moist clay and lard will impart an earthy taste to the latter, rendering it unsalable.

**82. Conditions for Satisfactory Bleaching.**—If the temperature of the material is too low, the coloring matter will not be taken from it by the fullers' earth. As a rule, the lower the temperature at which the bleach is carried out, the better will be the resultant product. It is necessary, however, to have a temperature sufficiently high to cause the absorption of the coloring matter present. So far as has been ascertained, the action of fullers' earth in bleaching lard, oils, etc. is purely physical, no chemical

reaction between the two taking place. The physical condition of the earth employed in bleaching greatly influences its efficacy. It has been demonstrated that two clays of the same chemical composition may act radically different in effecting a bleach. One would answer every requirement in this direction, while the other gave no indication of bleaching power, thus demonstrating the fact that the chemical composition plays no part in this process. The fullers' earth used in the packing houses is tested in a comparative and practical way, as will be explained further on.

**83. Lard Coolers.**—Many forms and varieties of coolers, or agitators, for lard are used. The upright, open tank, in which are revolving arms that work in conjunction with stationary arms on a fixed central shaft, is much used. While this style of cooler will perform the work satisfactorily, its chilling capacity is not sufficient for the large packing houses having daily outputs of carloads of refined lard. These agitators have a double shell through which cold water or brine circulates, thereby chilling and agitating the hot lard at the same time.

Another form of chilling apparatus is a long, semicylindrical tank, or box, in which is fitted a revolving, horizontal screw that alternately works in and out the hot lard, thus exposing it to the air. This cooler sets in continuously circulating ice-cold water. It is adapted only for small manufacturers.

**84. Lard Roll.**—The most modern, and perhaps the most convenient and economical, method of cooling bleached lard is by means of the lard roll, or cooling cylinder, shown in Fig. 6. These cylinders are made in all sizes, and are well adapted for quick chilling. They are cast in one piece of cast iron, and in the refinery are connected with a circulatory system of brine or ice water, thus keeping the surface of the roll constantly cooled. The lard flows on the top of the cylinder *a*, as it revolves, and by the time the lard reaches the attached scraper *c* it is chilled hard. The cooled lard falls into the trough *b* underneath, and is removed

therefrom by means of a pump or a spiral conveyer *d* adjacent to an agitator, where the lumps are broken up. The lard is then filled into the various packages from this agitator.

In some establishments, two rolls are used; one, chilled by ice water, receiving the hot lard, the other, chilled by refrigerated brine, finishing the chilling. Where large quantities of refined lard are made daily, the use of the lard roll is a necessary requisite for rapid working. These rolls revolve at a speed of about ten revolutions per minute and occupy a floor space of about 12 ft.  $\times$  6 ft. Their cost ranges from \$500 each, upwards.

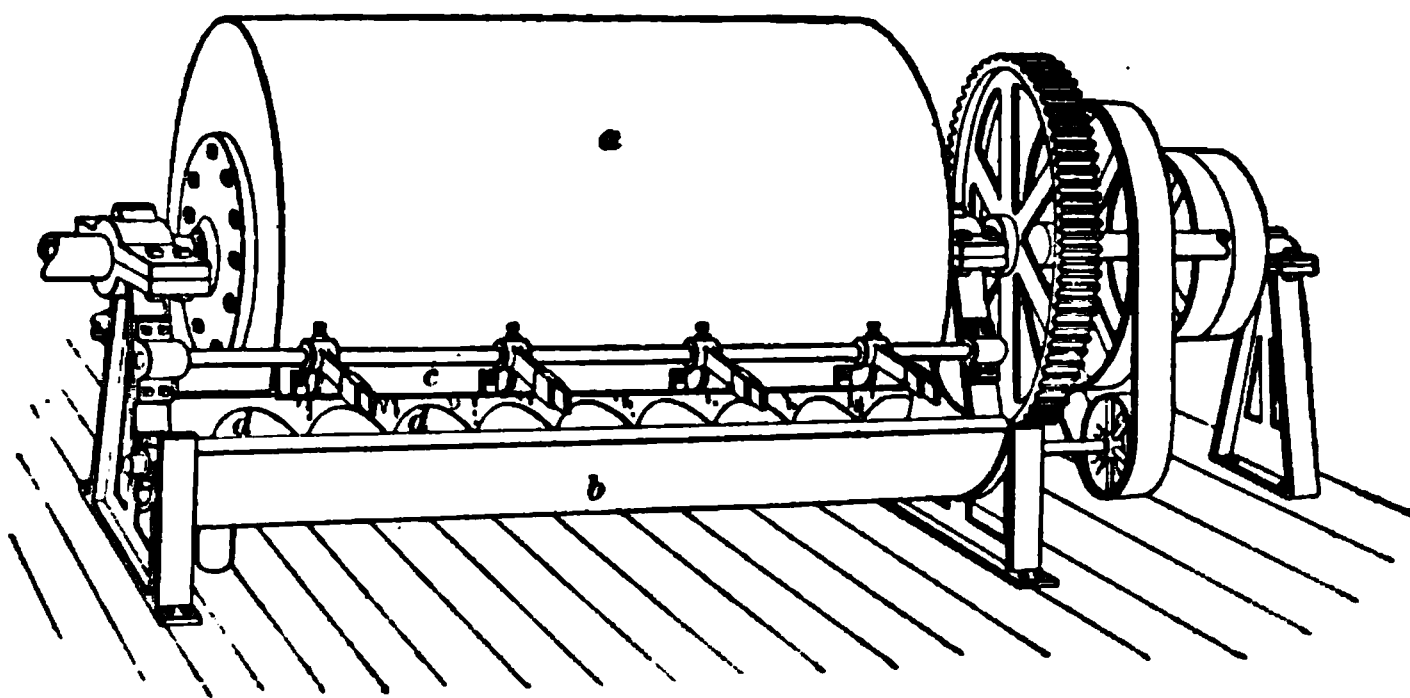


FIG. 6

A recent improvement on the lard roll consists in flowing the material on to the side of the roll, the arrangement of the scraper being such that the lard receives a much longer contact with the chilled surface of the roll.

#### KETTLE-RENDERED LARD

**85.** Leaf lard is an important product of the packing house, as it is the best grade made for household trade. While this lard was formerly popularly supposed to be made of leaf lard only, it never was made of that alone. The usual proportions of fat from which kettle-rendered lard is made are, approximately, one-third back fat and two-thirds leaf lard, though these proportions are varied at will (see Art. 9).

The lard material is filled into a steam-jacketed kettle, which is constructed so as to withstand pressure. The back fat has the rind, or skin, removed, and is put in and mixed with the leaf lard. A small amount of fluid rendered lard is put into the kettle before turning on the steam, to assist the material in rendering. The material is cooked until the natural moisture of the fats has been eliminated, which requires about 3 hours for a 3,000-pound batch. The hot lard, when freed from moisture, is quiet on the surface and free from rising steam bubbles. The steam pressure, as shown by the pressure gauge, should not exceed 10 pounds per square inch, which gives sufficient heat to cook the lard fully in the time just stated.

The cooked lard is allowed to remain in this kettle until all the fine scrap has settled; then it is either drawn directly off through strainers and muslin into packages or run into another settling tank, where it remains until wanted for filling into packages. The scrap remaining in the kettle is sent to the steam-lard tanks for further rendering to get any lard remaining in it.

Kettle-rendered lard that has been thoroughly cooked, if free from moisture and scrap, will keep for a long period, even under unfavorable circumstances. This lard, if properly made, does not require bleaching; but, if desired, it may be bleached in the usual manner with a small amount of fullers' earth. If the lard becomes burned, or if dark-colored material is used, bleaching is necessary to bring it to the required snowy whiteness.

**86.** Where large quantities of kettle-rendered lard are made, recourse is had to apparatus similar to that shown in Fig. 7. This apparatus is the same in every way as when making neutral lard, except that the kettle *D* is steam-jacketed instead of being water-jacketed. The lard material is hashed into the kettle and cooked the required time.

Kettle-rendered lard has a characteristic, distinctive, agreeable smell imparted to it by the method of cooking. Instead of rerendering the cooked scrap, it is often pressed in a lard

press, to recover as much lard as possible from it. This course is followed in small establishments where leaf lard is made, such as butcher shops, etc., and where there are no pressure tanks for further rendering. The residue remaining from this pressing is known as *cracklings*, from which the fertilizer material *azotine* is made. Cracklings are also used for making poultry food by mixing with ground bone. They always contain a very large percentage of fat.

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#### NEUTRAL LARD

**87.** Neutral lard differs radically from other lards, both in its nature and manufacture, and requires apparatus entirely different from that necessary for the production of the other kinds. This lard is made from leaf lard principally, but at times it is profitable to make it from material other than this, which will be described later.

**88. Process of Manufacturing Neutral Lard.**—The method of producing neutral lard is carried out as follows: The hot leaf lard from the hog is hung, each piece separately, on flat sticks, fitted into sections in the chill room, until the leaf has become thoroughly chilled, which requires at least from 24 to 48 hours. The best temperature for this is just above the freezing point, about 33° F. The leaf lard is then removed to the place of manufacture, which is situated in a part of the establishment remote from odors that might easily impart a taint to this susceptible material and thus render it useless as neutral lard. The apparatus and its arrangement is shown in Fig. 7.

The lard is introduced into the hasher *B*, which is driven by pulley *a* and revolves at a speed of about 600 revolutions a minute. The hasher is provided with a steam jacket through which live steam is constantly circulating during the period of hashing, or disintegration. The leaf lard is disintegrated into a plastic mass by the action of the revolving knives attached to the shaft of the pulley *a*, and falls through the spout *s* into the melting kettle *D*. This kettle

is water-jacketed; that is, the inside steel kettle is surrounded by another shell, between which is water, the temperature of the latter being regulated by live steam. The two kettles are not closed at the top, so that no pressure or temperature above that of boiling water is possible. The

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the chilling of the melting lard, caused by the cold lard constantly entering the melting kettle.

Only sufficient heat is given the water to keep the temperature rising about 1° in 5 minutes.



FIG. 7

**89.** It will require about 40 minutes to fill the average kettle, which holds about 3,000 pounds of material. The kettle,

filled to within about 6 inches of the top, will be at a temperature of about 126° F. The stirring is continued, keeping the temperature steady at this point for about 15 minutes, when all the lard will be melted. The latter operation is materially assisted by breaking any unmelted lumps with the hands. In about 5 minutes more the fine melted scrap will be seen to collect rapidly at the top, when the operation is completed. The steam is tightly shut off, the paddles, or agitator, raised free from the surface of the lard by means of the chains *m*, and the melting mixture allowed to remain at rest for 15 minutes. The temperature by this time will have risen to about 130° or 135° F., which temperature must in no case be exceeded.

The floating fine scrap from the leaf is then removed from the top, the last particles by a gauze skimmer. The removal of scrap is assisted by scattering about 6 or 7 pounds of fine salt over the surface of the lard. This also facilitates the removal of moisture (see Art. 68). The melted lard is now siphoned off by means of the pipe, with a swivel joint, attached to the side of the kettle; the outside end of this pipe is shown at *e*. The lard as it issues from *e* flows through a fine brass gauze sieve placed over the clarifying kettle *F*, to catch any floating scrap. This kettle is also water-jacketed. The neutral lard is allowed to remain in the clarifying kettle for 2 hours, when it is run through the siphon *g* into the settling kettle *H*, from which, after remaining at least 4 hours, it is drawn into the tierces.

**90. Packing and Graining.**—The lard must be held in the jacketed kettles at a temperature of about, but not more than, 130° F. When drawn into the tierces, the lard is strained through cheesecloth, to catch any possible fine, floating scrap. It should be filled in the tierces at this temperature and at once removed to the graining room, which is kept at as nearly uniform temperature as possible (between 55° and 60° F.). The 3-inch bungs in the sides of the tierces are removed when the tierces are placed on their sides, in order to allow as much lard odor as possible to escape.



After remaining undisturbed for 3 days, the lard will be found to have become of a *grainy* consistency. In other words, the stearin and olein of the lard have separated; the larger the grains of stearin, the choicer is the lard. When the lard is in this condition, the tierces may be moved at will; but if disturbed before this separation occurs, the lard will assume the uniform, smooth consistency of ordinary lard and be unsalable. The neutral lard, in the required grainy condition, is then finished and ready for shipment.

**91.** Returning to the melting kettle: After all the clear lard has been removed, the fibrous, brownish residue is let out through the pipe and valve *k* into a receptacle below. This residuum, consisting of water, scrap, and more or less lard, is sent to the rendering tank, in order to obtain, as prime steam lard, whatever has failed to be drawn into neutral lard. An analysis of the scrap removed from the top of the kettle was as follows:

	PER CENT.
Moisture . . . . .	3.70
Fiber . . . . .	28.91
Lard . . . . .	67.39
Total . . . . .	100.00

**92. Grades and Properties of Neutral Lard.**—There are no chemical requirements for neutral lard. The only trade requirements are purely physical, consisting of condition, taste, and complete absence of any odor whatever. The taste must be bland and more or less milk-like. The condition, as before mentioned, must be a sharp and decided separation of the stearin from the olein. The color of neutral lard is always snow white. The lard made from the leaf is known as *choice, No. 1, or extra neutral*.

**93.** When the price is suitable and favorable conditions prevail, a neutral lard, known as **No. 2 neutral**, may be made from back fat and fresh ham fat. This material is freed from the accompanying rind, or skin, and treated in the same manner as the leaf lard, with the exception of temperature. This material, containing a much larger pro-

portion of stearin, must be melted at a higher temperature to obtain a fair yield of neutral lard. The melting of this class of material takes place at a temperature of 136° F., the temperature rising to 142° F.—the limit to which it should be carried. The further treatment of settling, etc. is the same as that described for regular neutral lard.

**94. Uses of Neutral Lards.**—The principal use of neutral lard is for the making of oleomargarine, or butterine. As this lard is not fully cooked, but melted, its keeping qualities are very limited; hence, no attempts are made to cater to household trade. Neutral lard must always be kept in cold storage, or it will quickly acquire rancidity. The yield that may be obtained from average leaf lard is about 92 per cent. of neutral lard; from the residuum cooked under pressure, a further percentage of steam lard is obtained. The approximate cost of an apparatus to make neutral lard is about \$1,500, and, together with that shown in Fig. 7, it consists of a few minor utensils, such as trucks, strainers, etc. Neutral lard always brings a higher price than any other; the greater part of the product is exported, especially to Rotterdam, Holland.

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#### STIFFENED LARDS

**95.** In making lard for summer sale or for warm climates, it must be made of such consistency that it will remain in a more or less solid condition. This does not in any way apply to prime steam or neutral lards, but only to kettle-rendered lard and refined lard.

**96. Methods of Stiffening Lards.**—The most rational method of stiffening lard consists in selecting the stock before rendering, by using for steam lard or other purposes the softer parts of the fats, such as feet, and using only those parts which are naturally firm, from the greater amount of stearin contained in them, for the refined or kettle-rendered lard. While this method is largely practiced in establishments where such selection may easily be made, smaller packing houses are obliged to have recourse to

another method. This consists in adding to the lard, lard stearin in a proportion not exceeding 5 per cent. Lard stearin added to lard to this extent does not come under the head of an adulteration, as it is a natural constituent of the lard itself (see Art. 9). \_\_\_\_\_

#### **RULES REGULATING TRANSACTIONS IN LARD**

**97.** The following are excerpts from rules regulating transactions in lard among the members of the New York Produce Exchange, adopted at a meeting of the lard trade, held March 27, 1890, and amended March 18 and June 4, 1891, and July 6, 1897.

#### **PRIME LARD STANDARD**

**RULE 2.**—Prime lard shall be equal in quality to lard made from hog round, say head, gut, leaf, and trimmings, in the proportion in which the same come from the hog, and shall be properly rendered as to color, flavor, and soundness for keeping. The renderer's name shall be distinctly marked on each tierce at the time of packing with metallic brand, marking iron, or stencil.

#### **REGULAR TRADES**

**RULE 3.** *Sec. B.*—In the absence of any special agreement, all lard sold on the spot or to arrive shall be understood to be the standard quality of "prime lard," and which is generally termed in option trades, contract lard.

#### **PACKING AND COOPERAGE**

**RULE 4.**—Prime lard made between October 1 of any year and December 31 of the year following only shall be considered "standard," and a good delivery on contracts maturing during that time.

All lard to be classed as "standard" shall be packed in new cooperage made of well-seasoned white or burr oak, free from objectionable sap.

The dimensions of tierces shall be about as follows: 32 inches long with 21-inch head, or 33 inches long, with 20½-inch head; staves to be chamfered at the head; staves ¾ inch thick; head 1 inch in center and ¾ inch at bevel; hoops, hickory or white oak, or other good wood, to be hooped not less than 11-16.

**STANDARD WEIGHT OF TIERCES AND TANKS**

**RULE 5.**—Tierces shall contain not less than 310 pounds lard nor more than 370 pounds. The “standard” net weight of tierces of lard shall be 340 pounds, and any variation therefrom, when delivered on option contracts, shall be settled for at the settling price of the 11-o’clock call on the day of delivery. The number of packages contracted for must be delivered, and all tierces must have weights and tares marked thereon. Tanks, in the absence of any special agreement, shall be understood to contain 42,500 pounds net, or equal to 125 tierces of 340 pounds each. Any variation therefrom exceeding five per cent. (5%), either buyer or seller may have the right of settling at the market price on date of delivery.

**INSPECTORS AND WEIGHERS**

**RULE 6.**—All inspectors and weighers of lard for delivery on sale or contract under the rules of the Exchange must be members thereof, and licensed by the Board of Managers, and must obligate themselves not to buy or sell on their own account any article they are licensed to inspect or weigh. \* \* \* Fees of inspectors and weighers must be paid by the party employing them. \* \* \*

**WEIGHT, INSPECTION, AND TARES**

**RULE 7. Sec. A.**—The seller shall have the right to designate the weigher, but buyers shall have the right to designate an inspector; either shall have the right to appeal to the committee, as the case may be, whose decision shall be final and binding.

**Sec. B.**—To determine the tare on lard, four per cent. (4%) of the number of packages shall be tested at the expense of the seller. The tare should be ascertained by scraping the lard from the packages, and not by removal by dry heat or steam. The empty packages shall then be weighed and the lard replaced, and the weight of the refilled package shall be the gross weight.

**Sec. C.**—In testing for weight and tares, packages that are evidently mismarked shall be excluded from the average.

**Sec. D.**—All appeals from weight, inspection, and tares must be settled at the place of delivery unless otherwise agreed upon.

**Sec. E.**—Seller must give buyer timely notice to attend to inspection, weight, and tares. If buyer fails to attend to the same within a reasonable time, it shall be the duty of any two members of the committee on lard, upon such notice and failure, without fees, to appoint an inspector to sample the lard for delivery on that notice, and his inspection shall be final on that delivery.

LARD CALLS

RULE 9. *Sec. B.*—Unless otherwise specified, all offers to buy or sell shall be understood to be in lots of 250 tierces. Offers to buy or sell in larger quantities than above specified shall be in multiples thereof. \* \* \*

RULE 10.—Either party to a contract, prior to or upon signing the same, shall have the right to call an original margin of two dollars (\$2) per tierce on lard, and a further margin may be called from time to time to the extent of any variation in the market value from the contract price.

Where no original margin has been deposited, calls may be made from time to time to the extent of fifteen (15) cents per one hundred pounds (100 lb.) above or below the market price of lard. \* \* \*

METHOD AND FORM OF CONTRACTS

RULE 11.—The seller shall in every case make out the contracts, and after signing his side shall send them to the buyer not later than the day following the day of the sale. The buyer on receiving the contracts shall sign his side and return it to the seller not later than the second day after the sale.

Verbal contracts, when satisfactorily proven, shall have the same standing as written contracts; but the claim under such contracts must be made on the day of the alleged transaction, or on the next business day thereafter.

The following shall be the form of contract for lard sold for future delivery:

LARD CONTRACT

New York, . . . . . 18. .

In consideration of one dollar in hand paid, the receipt of which is hereby acknowledged, we have this day sold to (or bought from) . . . . . two hundred and fifty tierces Prime Lard, at . . . . . cents per pound, deliverable at seller's (or buyer's) option.

. . . . .

This contract is made in view of, and in all respects subject to, the By-Laws and Rules established by the New York Produce Exchange in force at this date.

TRANSFERABLE ORDER AND DELIVERY ON CONTRACT

RULE 14.— \* \* \* The lard shall be delivered in lots of two hundred and fifty (250) tierces at one time and one place. There shall not be more than one lot of less than fifty (50) tierces of one brand. Every order must have the weigher's name and place of business indorsed thereon.

\* \* \* \* \*

### APPEAL ON CONSTRUCTION OF RULES

**RULE 21. Sec. A.**—Any party feeling himself aggrieved by the decision of the committee on lard, in the interpretation of these rules, shall have the right to appeal to the board of managers of the Produce Exchange.

**Sec. B.**—All rules as to lard trades must be justly and liberally construed, and no property shall be rejected or condemned for merely technical reasons, but this shall not be regarded as giving license to departure from their general spirit and intent.

**Sec. C.**—All former rules of the lard trade, and the general rules of the lard and provision trades, prior to this date, so far as they apply to the lard trade, are hereby repealed.

No change shall be made in the rules by the committee on lard before submitting the same to a meeting of the lard trade, at which ten shall form a quorum.

### INSPECTION RATES

At a meeting of the lard trade, held May 16, 1892, the following were fixed as the minimum charges on lard handled in New York after this date:

Weighing . . . . .	Four cents per tierce
Inspection and marking . . . . .	Four cents per tierce
Stripping . . . . .	Fifty cents per tierce
Nailing . . . . .	Four cents per tierce

**NOTE.**—The following addition was made to the inspection rates at a meeting of the lard trade held July 6, 1897:  
Inspection and weighing \$5 per tank of 42,500 pounds.

### EDIBLE AND LARD COMPOUNDS

**98.** Lard compound and compound lard were at one time trade names by which a material consisting of no lard whatever was universally known. Various ingredients were used for making this, the main constituent being cottonseed oil. To this were added, in varying proportions, tallow and oleo stearin; either one, or both, was used at times in the same compound.

The method of preparation of edible, or cooking, compounds will now be described. These compounds, which were called *lard compounds* before the enactment of The Food and Drugs Act of 1906, are now sold under their true character

(see Art. 9). The following method of preparation—the chilling, bleaching, etc. of the various ingredients—is that by which the mixtures formerly known as lard compound were made.

**99. Ingredients Used in the Manufacture of Edible, or Cooking, Compounds.**—The proportion of the different ingredients in cooking compounds varies according to the season of the year, the locality to which it is destined, and the market prices of the different components. The formulas most largely used in the packing houses are as follows: For winter compound, cottonseed oil, 80 per cent., and oleo stearin, 20 per cent.; for summer compound, cottonseed oil, 75 per cent., and oleo stearin, 25 per cent. These proportions may be varied at will or according to circumstances. For example, when oleo stearin is high in price, it is replaced wholly or in part by edible tallow. In the summer formula just given, the proportions used could be, with equal results as to flavor, color, and general excellence, cottonseed oil, 75 per cent., oleo stearin, 15 per cent., and edible tallow, 10 per cent. The same is true of the winter formula.

For warm climates, a summer formula must be used for making the compound, while for cold climates, the winter formula may be used at all times. The object in the manufacture of this product when it was termed lard compound was to make it as nearly as possible like lard in color, texture, and appearance.

**100.** The *cottonseed oil* selected for lard, edible, or cooking compounds should be of as good quality as possible and should have as good a body as possible; that is, it should contain a notable amount of cottonseed stearin. Cottonseed oils that, on standing in a moderately warm place, deposit a white sediment (cottonseed stearin) should be given the preference over those which remain clear under the same conditions. When heavy-bodied oil is used, it requires less tallow or stearin to produce the required consistency, and as the latter products are the most expensive, it is a matter of economy.

The edible *oleo stearin* employed in lard and edible compounds should be selected with as high a titer as possible, for the same reasons as given for cottonseed oil. The harder the oleo stearin, the more of the cheaper product—cottonseed oil—can be used in the compound. One of the salient features in making this product is to employ as large an amount of cottonseed oil as possible and yet have the resultant product of the required stiffness, or consistency.

The *tallow* used for these compounds must in every case be edible tallow. The requirements in regard to hardness are the same for this as for oleo stearin.

While lard may not be used in making these compounds there are no reasons, except that of cost, that it cannot be used as a component. When lard is used for this purpose, the ordinary steam lard will answer all requirements.

Before compounding the different ingredients, they are bleached separately in the usual manner and afterwards mixed in the required proportions.

In bleaching cottonseed oil, the first step is to ascertain the approximate percentage of clay required to remove the natural yellow color. Some yellow oils are not susceptible of bleach, while others require such a large amount of clay that it is both dangerous and unprofitable to use them. The danger lies in imparting to the oil the undesirable earthy taste that, once acquired, cannot be eradicated.

**101.** In bleaching cottonseed oil, too high a temperature must be carefully guarded against, as should also the use of more clay than is necessary to accomplish the bleaching. A good temperature for bleaching is about 140° F., although this will vary one way or the other with the particular oil employed. For the usual compound, it is not necessary to bleach cottonseed oil water white, although if possible, without spending too much time and labor in bleaching, a compound of snowy whiteness is very desirable. The agitation, or sudden cooling, that the finished compound receives previous to drawing into the packages materially aids in imparting to it the desired white appearance. There being



no recognized standard, its usual creamy-white color is acceptable. In bleaching the tallow for use in compounds, a temperature of not over 120° to 125° F. should be the maximum. Good tallows bleach readily at this temperature. At too high a temperature, any tallow is likely to become very strong in taste and smell from the bleaching process, especially where a high temperature has been necessary to bleach it effectually. A small amount of edible mutton tallow may be used in cooking compounds without bleaching, but it is undesirable to use this material, as the strong mutton odor will make itself evident when the compound is subjected to a high heat, as it is in household use. Mutton stearin has also been employed as a substitute for oleo stearin in these compounds.

**102. Mixing the Compound.**—When all the materials have been bleached separately, they are stored in different tanks, or coolers, until called into use. The proportions of the different ingredients are weighed and united in the mixing tank, from which they are pumped through the filter press and chilled in the usual way, almost always as a rule, however, over the lard roll. The usual bleaching tank *A*, Fig. 5, conveniently serves the purpose of the mixing tank.

Cooking, edible, or lard compound, when being drawn into packages, is of such a consistency that a moment after the can is filled it may be inverted and the compound will remain in the can unaffected—neither flowing nor dropping out.

**103. Cottolene, Etc.**—Of late years, cooking compounds known under various trade names, as *cottolene*, *cotto-suet*, etc., have come into existence. These were designed to overcome the prejudice, largely existing, against the name *compound lard*. They are composed quite uniformly of cottonseed oil and beef suet in varying proportions. Many are made in the approximate proportions of 33 per cent. beef suet and 67 per cent. cottonseed oil. While these proportions vary somewhat, they may serve to produce compounds similar in all respects except the registered trade name.

Cottolene is the product of a concern in the United States, and its principal distinction from lard compound as formerly made consists in being manufactured from yellow, unbleached cottonseed oil. Later, this same company placed a white cottolene on the market. It is made from white cottonseed oil and the other usual ingredients of cooking compounds.

**104. Lard Compound.**—The methods of preparation just described are applicable in their entirety to the manufacture of lard compound, when more or less lard is added to the ingredients. This point is a matter of individual decision with each manufacturer, but in all cases the proportion of lard in lard compound must be equal to or greater than any other one of the ingredients (see Art 9). The lard used in the making of lard compound is the usual prime steam lard.



# PACKING-HOUSE INDUSTRIES

(PART 2)

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## VARIOUS ANIMAL PRODUCTS AND THEIR DISPOSITION—(Continued)

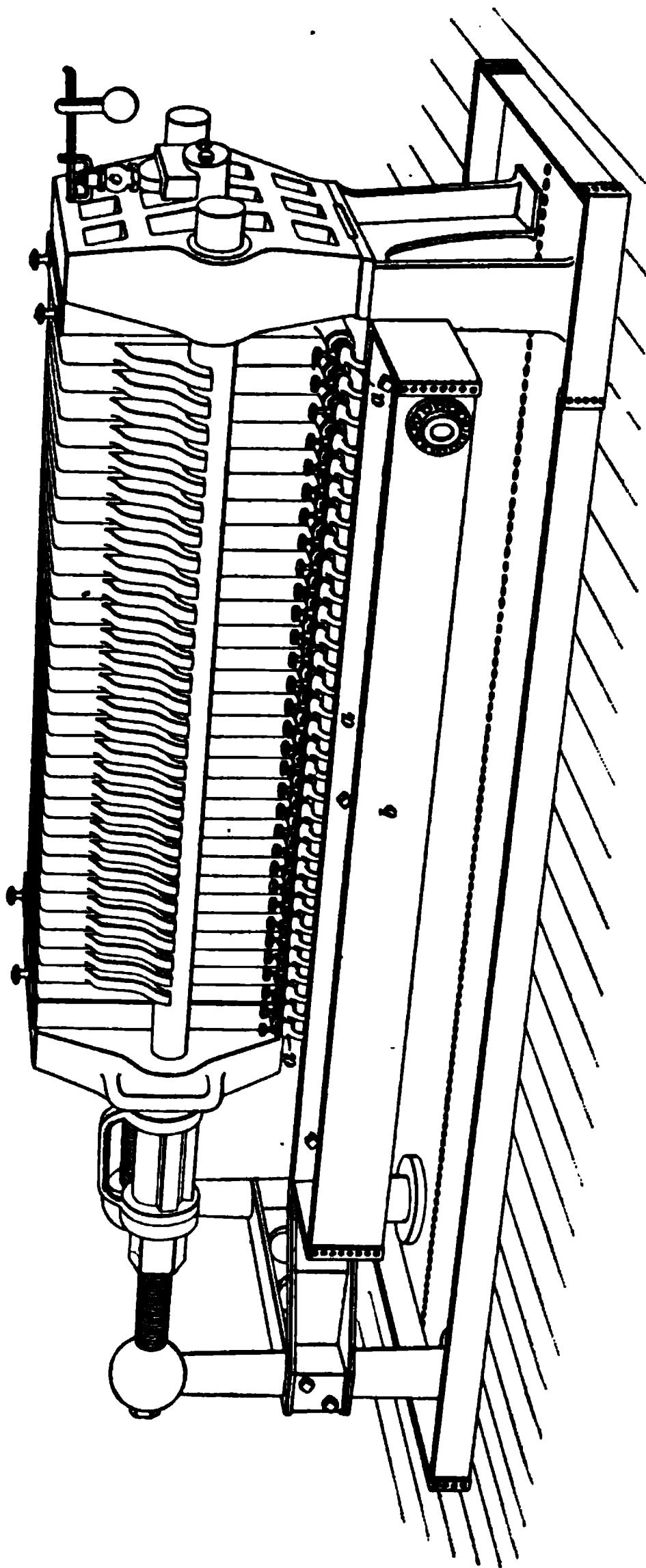
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### THE FILTER PRESS IN THE PACKING HOUSE

1. The use of the filter press in the packing house is, comparatively speaking, of recent date. This press is used for many operations and for the preparation of many packing-house products, among them being lard, oils, tallows, glues, and, at times, beef extract. The principal advantages of a filter press are: (1) The largest possible filtering surface in the smallest possible space; (2) the facility of forcing the material through the filtering medium (cloth) by the most suitable pressure, which varies from a slight pressure to a working pressure of 1,000 pounds to the square inch; (3) the ease with which the filter press may be handled; and (4) the rapidity of filtering large quantities of material at a very nominal cost.

2. **Construction of Filter Press.**—Filter presses are made with both square and round plates, and of all sizes and capacities. The square press, while not so convenient to handle as the round one, will hold more stock, and is more desirable on this account for packing-house use. The series of round or square plates of cast iron, or other suitable material is hung on the press rods. The plates have concave faces on each side, the rim, or outer edge, being

finished smooth and sufficiently wide to avoid unnecessary



wear on the filter cloths and the forming of tight joints. The concave surfaces of the plates are provided with grooves by means of which the filtered material, passes off. A hole in the center of each plate affords a channel through which the material to be filtered is forced when the press is charged.

FIG. 1

3. Fig. 1 illustrates a press of 24-inch square plates that is capable of producing an inch cake (between the plates) and has a working pressure of 150 pounds per square inch. One chamber of this press will hold 484 cubic inches of material to be filtered. A press like this will filter from 7,000 to 8,000 pounds of lard per hour.

4. Fig. 2 illustrates a single plate of a filter press, a view of the perforated metal front and also of the center clamp being shown. This plate has an outlet cock attached for drawing off the filtered material. The plates are covered with the filter cloths, which are placed on each side, are fastened at the center by means of adjustable screw nuts, and are held in place by adjustable fastenings, as shown. When all the plates are covered with the cloths, they are forced together by a follower, which is actuated by a screw, and are tightened by a long lever; or, in some cases, depending on the form of press, by a lever wheel, or by a hand-wheel ratchet lever. Different presses are provided with different means of closing.

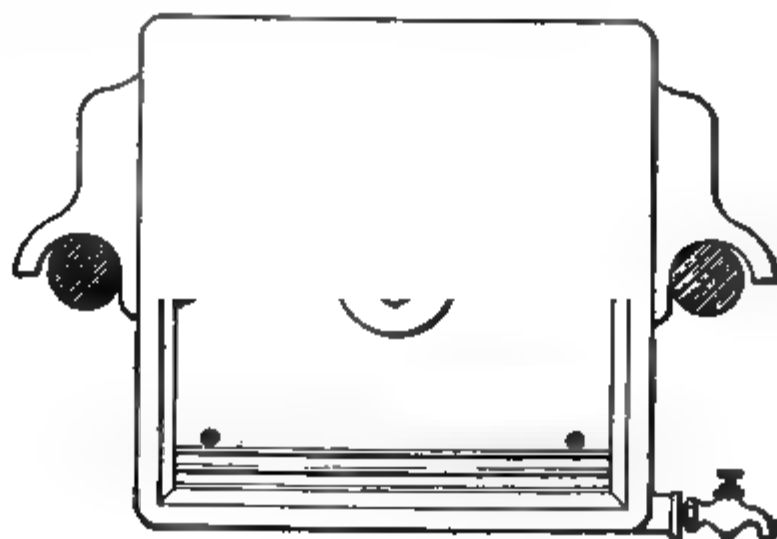


FIG. 2

5. A recent improvement on filter-press plates is shown in Fig. 3. This improvement consists in having a delivery channel at the bottom of the plate, as shown. This channel, it is claimed, increases the capacity of the filter plate 25 per cent. These plates are made both round and square and with a corrugated or a pyramidal surface, the latter being shown in the figure.

6. **Filter-Press Cloth.**—An important condition in the attainment of satisfactory results consists in the filter-press cloths being of good material. The fabric must be pliable, yet closely woven, so that while giving a clear filtrate, it will be sufficiently strong to withstand the heavy pressure

exerted by the pump when forcing the oil or the lard through the press. Either heavy drilling or cotton duck is suitable for packing-house use.

**7. Operation of the Filter Press.**—When the pump is running, the material to be filtered is forced through the center channel, filling all the chambers in the plates. The pressure forces the liquid through the cloths to the surface of the plates, and it passes down the grooves, or channels, on the face, through the outlets *a*, Fig. 1, in the plates, and then into the receptacle, or trough, *b* beneath. The impuri-

FIG. 8

ties and bleaching material, such as fullers' earth, are retained by the cloths.

The filter press is provided with a safety valve, or outlet, *c* through which, when undue pressure is exerted on the press by the pump, the material may find an outlet. This safety valve prevents the press or the cloths from bursting, which is liable to occur when wet or moist clay is mixed with lard, tallow, or similar material and efforts are made to force this mixture through the filter press. The valve may be set to operate at any desired pressure, but for packing-house work, 150 pounds per square inch is sufficient. Some filter presses

are built with a top feed, the valves being so arranged that only a part or all of the press may be used at one time.

It is sometimes desirable to filter quantities so small as not to fill all the plates of the press. In this case, a blank, or dummy, plate, which is a solid plate without a center channel, is used to cut off any portion of the press. To use the dummy plate, it is inserted between any two plates where the flow is to be cut off. For example, if only five chambers of the press are wanted for use, the dummy plate is inserted between the fifth and sixth plates and the press screwed tight. In this manner, a perfect working press of five chambers is made. The dummy plate is very convenient and should accompany every filter press.

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## TALLOW, GREASES, AND OILS

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### TALLOW

8. **Tallow** is the rendered fat of cattle, calves, and sheep. Goats are occasionally slaughtered in the packing houses in the United States, but their number at the present time is of no industrial importance (see *Packing-House Industries*, Part 1), although their fat may also be rendered into tallow.

The tallows emanating from the packing house include *edible, prime, packer's* (No. 1, or *packer B, tallow*), and *No. 2 tallows*, and, at times, *acidless cylinder tallow* and *cake tallow*. Sometimes, other tallows with special designation are made, but those just mentioned are the ones usually produced.

Between the ordinary tallow and oleo stearin comes the *tallow stearin*, an article having some of the characteristics of both the former products. The manufacture of tallow stearin will be described later.

9. **Edible Tallow.**—The highest grade of tallow is that known as **edible tallow**, which, as its name implies, is used in food compounds, such as lard and “cotto” compounds,



etc. Edible tallow is made of high-grade beef fats that have been subjected to thorough washing in ice water so as to remove the blood and other impurities before placing them in the tank for rendering. The fat undergoes another washing in the tank, this time, however, in heated water. The tank is then closed, and the fat is rendered under pressure. Fats from which edible tallow is made are of a grade suitable for the making of oleo oil and stearin, but are of a troublesome, small size.

When the price of oleo products is low, this tallow is frequently made of the butter fat itself. The material is carefully rendered in the usual manner, especial care being taken, however, not to subject it to too high a temperature or to cook it too long. A pressure of 25 pounds of steam per square inch for 8 hours will give good results in making a high-grade material. As an advanced price over the regular prime tallow is always obtained, the extra preparation and care is thus repaid. This tallow is now extensively made, as the demand for it is very great, being used for the manufacture of lard and edible (cooking) compounds. The hardness, or titer, of this product is not of such moment as the amount of free fatty acid, which must not exceed  $\frac{1}{2}$  per cent.

**10. Prime Tallow.**—The tallow made of the usual run of fat from the bullock, that is, the material consisting of the fat ordinarily selected for the manufacture of oleo oil and oleo stearin, together with the other portions of good, sweet (not putrefied) fat, is known as **prime tallow**. The material is cooked together in the pressure tank, being subjected beforehand to the usual washing in the tank. A pressure of 30 pounds of steam per square inch for 5 hours is used in the usual method of cooking. The color of this material when drawn into barrels and chilled must be a clear yellow, and not grayish or of any decided shade; if white and clear, it is more desirable. The free fatty acids in this tallow should not exceed 4 or 5 per cent., and the titer should be around 42° C.

**11. No. 1 Tallow.**—The tallow most extensively produced in the packing house is the ordinary tallow of trade known as **packer's**, or **No. 1, tallow**. This product is made of the regular run of fatty material (other than the material picked for oleo making), consisting of all fats of any description from the bullock, calf, and sheep, which, when rendered, will produce a tallow of good or fairly good yellowish color. The stock for No. 1 tallow is subjected to soaking and washing in the tank before rendering, as, in common with all material of this nature, the more washing it receives, the better will be the resulting product. As this fatty material is nearly always accompanied by more or less filth, slime, and dirt, vigorous washing is frequently necessary in order to produce an article grading as No. 1 tallow.

The same cooking that is given to the prime tallow is given to this. The lighter the color and the cleaner the tallow, the better the market price and sale. The free fatty acids in this tallow are seldom considered by users, although much closer attention is now given to their presence in this particular grade of tallow than formerly. Ordinarily, if of good color and practically free from moisture and impurities (less than  $1\frac{1}{2}$  per cent.), No. 1 tallow is accepted at a price depending to a great extent on its hardness.

This tallow usually has a titer of about  $41^{\circ}$  C. If the titer is lower than this, a reduction in price must be expected; and if higher in titer, a corresponding advance can be obtained. At the present time, besides the test for titer, this tallow is subjected to chemical analysis for moisture and impurities, on the results of which sales are based. The industrial uses of this tallow are too well known to be mentioned. As the titer of tallows is such an important feature, both for the producer and the consumer, a detailed method for its determination will be given further on.

**12. No. 2 Tallow.**—The grade known as **No. 2 tallow** is made of all tallow-yielding material from which the other selections have previously been made and of the pressings of the beef tankage and fertilizer material. It is the final

place to which any and all kinds of tallow-yielding stock is consigned. There are no especial requirements for this tallow other than freedom from moisture and impurities. There is no recognized standard, each lot being sold on its own merits, in respect to the features just stated and its titer.

The color of No. 2 tallow varies widely—from yellowish green to brownish. The free fatty acids are frequently as high as 20 per cent. or even more, depending on the source of material from which the tallow is made. The tallow derived from livers, lungs, floor scrapings, etc. also constitutes No. 2 grade. It is never bleached and is seldom pressed for oil. The industrial uses of this tallow are principally for distilling into oleic and stearic acids and glycerine. A small amount is consumed by soap makers. When the percentage of free fatty acids is excessive, this tallow cannot be used profitably for the production of glycerine or stearic acid.

The offal of calves is placed with the beef material, yielding a small quantity of No. 1 tallow and a very little No. 2 tallow.

**13. Acidless Cylinder Tallow.**—Tallow of good grade, the fatty acids of which do not exceed 5 or 6 per cent., is used for making **acidless cylinder tallow**. The operation of making this acidless tallow is carried out in the same way as the making of tallow oil into the acidless condition, which will be described later. This tallow has at the present time a more or less limited sale, being used principally as a lubricant for locomotive and other engine cylinders in localities where lubricating oil is inconvenient to obtain or to handle. It is also used for compounding with other materials for the making of lubricants for various industrial purposes.

**14. Cake Tallow.**—The name **cake tallow** is derived from the shape of the finished product. This tallow is of good grade and has a titer of at least 44° C. The form, or shape, of the cakes is a matter of individual taste, the most common form, however, being a cake about 3 inches thick

and 6 inches square. The cakes usually weigh 5 pounds each, and they are generally packed in boxes having a capacity of twenty cakes.

Cake tallow is generally white in color, but need not be, if the requirements as to hardness and freedom from impurities are acceptable. The harder the tallow, the better it suits the consumer. This tallow is made by running the warm and molten tallow into sheet-iron molds of the required dimensions and chilling quickly by any convenient means, without allowing the material to grain by separating into oil and stearin. The cakes when thoroughly chilled may be easily knocked from the pans and immediately packed.

This tallow costs about a quarter of a cent a pound more to make than tierce tallow, but the selling price greatly exceeds this extra cost. It is a very profitable article of manufacture. Cake tallow finds use in the lumber regions, both for lubricating machinery and for lubricating the runways for logs. In the lumber industry, owing to its general utility, this tallow has not yet been replaced by oils. When tallow suitable in all respects for cake tallow, except in hardness, is wanted for this purpose, an addition of a few per cent. of tallow stearin will enable it to fill the requirements.

**15. Mutton Tallow.**—Where large numbers of sheep are slaughtered, the tallow from the offal is cooked by itself and produces a white, hard tallow known as mutton tallow. The usual method is to cook the heads and other material, other than lungs, livers, and feet, in an open vat with live steam for from 10 to 12 hours. After a period of settling, the resulting tallow is collected, freed from water, and tierced. The offal from the intestines, feet, etc. produces a dark-colored material, which is tanked with the usual material for No. 2 tallow.

The tankage remaining from the open cooking in the vats is again cooked under pressure with the ordinary No. 1 tallow stock, materially contributing, if in any quantity, to raising the titer of that grade. Mutton tallow has a titer of from 44° to 48° C., the latter when made of the caul and

kidney fat. This tallow is very serviceable for the making of cake tallow.

**16. Yield of Tallow.**—The yield of tallow from fat is extremely variable, depending very much on the material from which it is made. When the total fat of a bullock, other than that left with the dressed beef, is tanked, the yield approaches from 74 to 78 per cent. of tallow. This includes the caul fat and the other parts generally selected for oleo oil and stearin. This yield can be increased to 80 per cent. by careful and thorough pressing of the cooked tankage after rendering.

When the general run of fat for ordinary tallow is tanked and the highest grades removed, the yield approximates from 68 to 72 per cent. of the material cooked. The amount of tallow obtained in all cases depends on the quality and fatness of the animals slaughtered, together with the care taken in rendering.

The yield of tallow from bones, as with other things, is exceedingly variable. When tallow is derived from bones alone, it is known in the packing house as *butter-stock tallow*. This tallow is in reality a bone oil. It is a soft, yellowish-white material that may be, and at times is, utilized in making the lower grades of oleo oil. The tallow obtained from the heads of cattle is the same material as that derived from the other bones. It has a titer of about 42° to 42.5° C.

Kidney fat when tanked by itself may be made to yield from 90 to 95 per cent., the latter in exceptional cases. Caul fat and ruffle fat when cooked under pressure will yield from 78 to 84 per cent., depending on the quality of the cattle from which these fats are taken.

**17. Bleaching of Tallow.**—Besides the usual bleaching of tallows with fullers' earth, a mixture of sulphuric and nitric acids in equal proportions is sometimes employed for this purpose, but seldom, if ever, in the packing house. This treatment also hardens the tallow by the chemical action of the nitric acid on the oleic acid, transforming some of the latter into palmitic acid. For 100 pounds of tallow

treated for bleaching and hardening, 1 pound each of sulphuric and nitric acids, considerably diluted with water, is used, the tallow being washed afterwards to eliminate the excess of acid not used up. Great care is required in this process, which is applicable only with hot stock and in a wooden or a lead-lined tank. This treatment of tallow should always be preceded by a laboratory experiment, in order to ascertain the exact quantities necessary for each lot designed to be treated. Otherwise, a large quantity of material may be seriously damaged.

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#### GREASES

**18. Grade A White Grease.**—Greases in the packing house are divided into several grades. The highest grade, **A white**, is made of hog material that would normally make lard, but for various reasons is made into white grease (see *Packing-House Industries*, Part 1). All hogs condemned before or at slaughter and condemned pork material furnish the source of this grease. It is very similar to lard in appearance, odor, and color, and is in fact a lard except in name and purity. This material furnishes a source of winter-strained lard oil. The stearin from it is not sold as lard stearin, but must be branded "white-grease stearin."

**19. Grade B White Grease.**—Next in grade is **B white grease**. This grease is obtained from material that is not dark or discolored, the resulting grease being of a light-fawn or buff color and having a strong, more or less rank, odor. Boiled-out ham grease, sausage-room grease, and the grease from spoiled fresh meat are a plentiful source of grade B white grease. The lard oil from B white grease is generally light in color, but usually makes no better grade than extra No. 1 lard oil; at times, it may make an "off-prime" lard oil.

**20. Yellow Grease.**—The grade known as **yellow grease** is made of rather dark-colored material or good-grade material intermixed with a small quantity of poor material. For example, grease from ham boiling, which by

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itself is B white, when mixed with grease from the livers, lungs, etc. becomes yellow grease. In small establishments where all grease material is cooked together, the resultant product is yellow grease. This grease has a strong, rather nauseating odor, and the color, as the name indicates, is yellowish. On pressing, yellow grease yields No. 1 lard oil and yellow-grease stearin. If light in color, the yellow grease may yield an extra No. 1 lard oil.

**21. Brown Grease.**—The grade known as **brown grease** is made of all refuse grease-yielding material in the packing house. The pressed-out grease from tankage is placed with this. The dark-colored, greenish-black grease yielded from livers, lungs, and floor scrapings is brown grease. This grease is largely exported to France for distillation into olein, stearin, etc. It is also consumed in a small way in the manufacture of cheap soaps, axle grease, etc. On pressing this material, No. 2 lard oil and brown-grease stearin are obtained. Brown grease from hog material corresponds with No. 2 tallow from beef material.

**22. Methods of Obtaining Grease.**—Greases are obtained from the fatty material in the same way as lard, the process being carried out in exactly the same manner. Greases of good grade are washed in the tank in the same way as lard material, but with the lower grades, such as yellow and brown, no washing is performed. In fact, it would be a waste of time and labor to wash the cheaper grades, as no profitable results would be derived from this operation; that is, even if the grease were made a shade or two lighter than usual, it would command no higher price on account of this single characteristic. The tankage from grease material is treated in the same way as the regular lard tankage.

**23. Bleaching of Greases.**—Greases are seldom bleached by means of fullers' earth, although, if it can be done economically, there are no objections to the practice. But, as a rule, owing to the time and labor, together with the cost of materials, shrinkage, etc., bleaching is seldom a

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paying process, the enhanced value of the grease not warranting the expense.

In order to make greases of dark color more acceptable to the soap maker, they are frequently treated with chemical bleaches. With some greases not too black, the use of such a bleach is often an inexpensive and profitable method of making light-colored greases. In the large packing houses, chemical bleaches are not used, the greases being sold in their original condition as made.

**24.** The following method is very serviceable for bleaching light greases: For every 500 pounds of stock,  $\frac{1}{2}$  pound of potassium carbonate, 2 ounces of sodium acetate, and  $\frac{1}{2}$  pound of borax are dissolved in 2 quarts of hot water, and this solution is added slowly to the grease, which should be heated to 160° F. The heating is continued while the material is being constantly agitated, by any convenient means, until a temperature of 200° F. is reached, when the heat is shut off and the material is allowed to settle. When cooled to 125° F., the bleached material is drawn off through muslin or a double thickness of cheesecloth, to free it from floating scrap, etc.

Another bleach applicable to the same grade of greases consists of 1 pound each of boracic acid and potassium chloride and  $\frac{1}{2}$  pound of saltpeter, the whole being well mixed. The material to be bleached is treated with the mixed chemicals in the proportion of 1 ounce to every 30 pounds of grease stock.

**25.** The following process is extensively used where large quantities of grease are to be bleached. It is a modification of Watts's bleaching process and is employed very successfully; hence, it is given in detail. It is advisable, as is always done in the packing houses with all materials of this nature, to experiment on small quantities of material before handling larger quantities. The green color occasioned by the chromic compounds sometimes clings persistently to the grease, but thorough washings will eventually remove it. The method of procedure is as follows:



For 20 barrels of grease, dissolve 3 pounds of potassium bichromate, 1 pound of sal soda, and 4 pounds of potassium permanganate in 5 barrels of water. Run this mixed solution into the melted grease, which should be only warm enough to liquefy it. Then thoroughly mix the preceding solution with the grease by applying a strong current of air for about 30 minutes. Now mix 8 quarts of 66° Baumé sulphuric acid with 6 quarts of water, taking care to pour the acid into the water (not reversing the proceeding), and add this diluted acid to the mixture of grease and solution of chemicals, thoroughly mixing the whole by air-currents from an air compressor or blower. When the grease turns green, turn on steam. After 5 minutes has elapsed, turn off the air, but leave the steam on and bring the mixture to a lively boil. When boiled for 10 minutes, turn off the steam and allow the mixture to settle for from 10 to 20 minutes. Draw off the mixture of water and chemicals and turn on a spray of water from a hose, using clean, hot water. Allow the water to settle and draw it off. (This may necessitate warming the grease again if it has cooled too much.) In the meantime,  $\frac{1}{2}$  pound of sal soda should be dissolved in 50 gallons of water in another tank—the washing tank. The grease bleached in the previous operation is run off into this washing tank and boiled with the sal-soda solution for 2 hours. The steam is then turned off and the water is allowed to settle, after which it is drawn off, leaving a light-colored, almost odorless, grease. This formula is effective for ordinary grades of grease. For very poor grades, the amount of chemicals must be increased, even doubled, without, however, increasing the amount of water.

**26.** The most suitable tanks for treating twenty tierces of grease (bleaching as well as washing) are built of 2-inch wooden staves. These tanks are 4 feet in diameter at the bottom, 7 feet in diameter at the top, and 10 feet high. For treating very poor greases, when relatively strong solutions of the chemicals are used, the tanks are preferably painted with a good asphaltum paint that is impervious to acids,

etc. Each tank must be provided with air-blower pipes, open steam pipe, closed steam coil, and draw-off cocks for water and grease.

Occasionally, a grease will retain color and odor in a most obstinate manner, but a grease that will not give a satisfactory result is seldom found if the foregoing directions are closely followed. Some greases can be materially improved by subjecting them finally to a bleach with fullers' earth; usually, however, the grease is acceptable and preferable without the treatment last named. Contact with copper or brass cocks must be avoided in this process. A large quantity of water and good blowing, or agitation, is necessary to eliminate the smell occasioned by the chemicals. There should always be sufficient acid, so that an excess will be present, or the reaction will not take place. This excess is readily washed out by hot water, the ordinary wooden vats, such as are used in a packing house, being suitable for this operation.

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#### . OILS

**27. Oleo Oil.**—Among the products of the modern packing house, oleo oil is of great importance, as it forms a most profitable outlet for a large part of the fat of the bullock that otherwise would be rendered into ordinary tallow. In the manufacture of oleo oil, scrupulous cleanliness is a most important consideration, as without it no first-class product can be obtained, even if the best possible material is used. While cleanliness is important, necessary, and even obligatory everywhere in the packing house and with all products, oleo oil is probably the most sensitive of all to deterioration from uncleanly conditions.

The beef fats used in the manufacture of the highest grades of oleo oils are technically known as *butter fat*, and consist of the *omentum*, or *caul fat*, *ruffle fat* (the apron of fat to which the intestines are attached), and the fat of the *heart*. Other fats may be used, but only those mentioned can be used for the best grade. There are generally two grades of oleo oil made, but when the price of this product is high, a third grade is

made. To make the latter, under ordinary conditions, is not a paying investment. For this grade, pieces of beef fat of any sort in good condition may be used.

Oleo oils are always sold by the purchaser's inspection. The requirements are absence of pronounced odor, a clean, bland taste, and a well-defined grainy condition, all being essential for successful and profitable sale. The absence of any one requirement causes a material difference in price.

**28. Preparation of the Fats for the Manufacture of Oleo Oil.**—The starting point to obtain good oleo oil is when the fat is removed from the slaughtered animal. The fat must not be allowed to touch the floor of the slaughter house nor be placed in any unclean receptacle. It is taken from the animal and immediately placed in vats of cold water, the temperature of the latter being kept at about 50° F. The fat is allowed to remain here for several hours, when it is transferred to another vat of clean water of much lower temperature. After remaining here for some time, until the animal heat has been eliminated, the fat is placed in water in which pieces of ice are kept, in order that the fat may be thoroughly chilled before being hashed.

The object of putting the fat into colder water gradually is to avoid hard chilling on the surface of the heavy pieces. In this way the animal heat from the middle is prevented from escaping through this solidified part of the fat. If this course were not followed, the heat retained in the interior of the fat would very quickly cause it to become "sour" and unfit for the best and edible grades of oil. These successive transfers of the fat require about 10 or 12 hours, it being kept in the iced water until about an hour before it is wanted for hashing, which operation precedes the melting of fat into oil. The raw material should not be kept over 48 hours before making into oil, and it is better if used within 24 hours.

The general arrangement of a plant for the manufacture of oleo oil is the same as that shown in Fig. 7, *Packing-House Industries*, Part 1. The operation is conducted quite similarly to that of making neutral lard, but differs in some

important details, notably in the higher temperatures employed.

**29. Process of Manufacture of Oleo Oil.**—The chilled beef fat is placed in the hasher and disintegrated in the same way as leaf lard. The same apparatus may be, and often is, employed for the manufacture of both oleo oil and neutral lard. The finely minced fat is allowed to flow through the spout *s* of the apparatus shown in Fig. 7, *Packing-House Industries*, Part 1, into the melting kettle *D* until the kettle (previously warmed before starting) is filled to within a foot of the top. The paddles attached to the shaft *c* stir the mixture continuously during the operation. Heat is applied gradually and continuously to the water in the jacket, until, when the kettle has been filled with the minced fat, the temperature is around 155° to 160° F.

The melting fat is cooked at this temperature for 1½ hours, when the operation is completed. The paddles are raised free from the fat, and a quantity of salt is scattered freely over the surface of the melted oil, to cause the scrap and water in it to settle below the oil. The material is allowed to rest for 20 or 30 minutes, when the clear, supernatant oil is carefully siphoned off by means of the attached siphon, the outside leg of which is shown at *e*.

The oil flows through a cloth strainer, to remove floating scrap, into the kettle *F*, where a further separation of fine scrap and moisture takes place. After remaining here at a temperature of not less than 130° F. for an hour, the oil is again siphoned by the pipe *g* into the settling kettle *H*. All these kettles are provided with water-jackets, as experience has shown that a dry heat on oleo oil is very detrimental to its quality.

The oleo oil remains in the final kettle for not less than 3 hours at a temperature not over 130° F. From this kettle it is run into seeding trucks at a temperature of 130° F. A few degrees from this either way materially alters the character of the *stock*, this being the term for the seeded, or grainy, mixture of oil and stearin. The warm material in

the seeding trucks is placed in a room that is free from drafts and protected from direct sunlight and allowed to remain there for 48 hours. This is done so that the stock will resolve itself into the oily and the hard parts of the original tallow or into olein and stearin. The temperature of the *seeding room* must be steadily maintained at 90° F.

The scrap and water remaining in the melting kettle *D* is withdrawn through the valve *k* and sent to the tallow-rendering tank, so as to get the tallow not obtained at the mild melting temperature. The kettle is thoroughly cleansed, when it is again ready for another charge.

**30. Pressing the Oleo Stock.**—After the stock in the seeding trucks has assumed the required condition for pressing, it is taken to the pressing room. The oil and stearin by this time are distinctly separated, yet intimately mixed. The material is thoroughly and uniformly mixed with the hands, placed in cloths laid over a mold, and wrapped in the form of a cake. To facilitate working, these molds are made on a circular revolving table, so that, with one man filling cloths, one folding into cakes, and another placing them in the press, the work proceeds very rapidly.

**31.** The form of press used for this work is illustrated in Fig. 4, the iron press plates not being shown. This press is known as the **knuckle-joint press**, and is run by power. The speed of the press is regulated by pulleys, for a rapid or slow descent, as desired.

**32.** The cloths for pressing the stock are of heavy, closely woven duck, strong enough to withstand the high pressure applied on them. This point is one of many where close attention to small details is necessary in order to produce a high-grade article. Neglect of this point alone would be the cause of an inferior product even if all other parts of the manufacture were properly carried out. After each day's run, the press cloths must be thoroughly washed and dried free from all moisture. While cloths for pressing other oils may be used several times without washing and drying, those for pressing oleo oil are used only one day.

The material, folded in the cloths in the form of cakes, is placed in the press on the bottom fixed plate until the latter is covered with a sufficient number of wrapped-up cakes. A sheet-iron plate is then inserted in the press and dropped on the cakes. This plate in turn is filled with material and another plate inserted above, this performance being repeated until the press is filled to its capacity, which



FIG. 4

varies with the size of the press used. The oily part of the stock begins to run out long before the press is filled, owing to the weight of the upper plates and material pressing on the lower layers. This is the oleo oil, or, as it is termed in Europe, *oleomargarine*. This term must not be confounded with the American name *oleomargarine*, which name applies exclusively to factitious butter, or butterine.

The oil flows to the settling receptacle, which should be water-jacketed, the flow of the oil being augmented by the ram of the press slowly descending and pressing the material. The speed of the press while pressing is very slow, occasional periods of rest from descending being allowed in order to give the oil time to ooze from the stearin. The operation of pressing is completed in about 30 minutes, but the stearin in the bags has the pressure left on it an hour or so longer, to give the material ample time to drain. When the stearin is free from oil, the ram of the press is rapidly raised by the fast motion of the press, and the latter unloaded, the operation being exactly the reverse of filling. The oleo stearin is removed from the cloths by unfolding and shaking them and the press is then ready for another charge. The temperature of the press room should always be maintained around 90° F.

There is always more or less waste incidental to the pressing of oleo or any other material. This waste is practically recovered when washing the press cloths, utensils, etc., and in the case of oleo stock is placed with the tallow stearin. The loss on pressing is usually regarded as 1 per cent., and tests are figured on that basis unless the loss is actually shown to be greater.

**33.** The oleo oil from the pressing is held for a short settling period in the reservoir, from which, at a temperature of 92° F., it is drawn into tierces. These tierces are immediately placed in a temperature of 55° to 60° F., so that the oil will acquire the requisite grainy condition. The temperature must be kept within these limits to insure successful graining, which takes place in from 5 to 6 days, and sometimes in even less time. When placed in the graining temperature, the 3-inch side bungs of the tierces are removed, to allow heat and any possible odor to escape.

Oleo oil finds exclusive use in the manufacture of oleo-margarine, or butterine. The greater part of this oil is exported to Holland, from which point it is distributed throughout the various European markets.

Oleo oil should have a titer not exceeding 40° C.; but at times this may be exceeded without detriment, as the oil is not purchased on its titer test, but on its physical characteristics only, as noted. As the raw fat from which this material is made is kept in a cold, fresh condition, free fatty acids cannot be generated, and, consequently, the free-fatty-acid tests of oleo oil will show ordinarily less than  $\frac{1}{2}$  per cent. Good oleo oil contains only .2 or .3 per cent. of free fatty acids. The yield of oleo stock from fat is from 65 to 70 per cent. or more, and the yield from pressing the grained stock is about 50 per cent. each of oleo oil and oleo stearin. This percentage yield is governed largely by market conditions and prices, the manufacturer inclining to the greatest yield in the highest-priced product, whether oil or stearin. Oleo oil is colored at times for certain trades by means of pure annatto.

**34. Oleo Stearin.**—After the oleo oil is pressed out as just described, the oleo stearin is shaken free from the cloths into a bin, and from this it is filled into large, thin-staved tierces, which weigh approximately 600 pounds when filled. The oleo stearin is pounded as compactly as possible into these tierces, the object being to have as little air as possible intermixed with the material, and also to have the tierces hold as much material as can be pounded in with a large wooden maul. For export purposes, the stearin is sometimes melted and run into tierces, the material in this condition retaining its sound condition for a very long period. Oleo stearin finds a very large outlet in the tanning and leather trades, and is used extensively for soap and candle purposes. It is also used in the manufacture of lard, cooking, or edible, compounds.

Oleo stearin is pressed so that it will have a titer of from 48° to 52° C.—generally averaging about 50° C. The harder the oleo stock is pressed, the harder the stearin will be until the limit is reached. This is about 52° to 53° C; but oleo stearin of this titer is never made commercially. To pass sale requirements, however, the titer must be at least 48° C.



The apparatus required for making oleo oil and stearin comprises the kettles illustrated in Fig. 7, *Packing-House Industries*, Part 1, and an oleo press, as shown in Fig. 3, together with the necessary seeding trucks, cloths, wringer for the cloths, skimmers, etc. The complete outfit, not including boilers, power, or building, may be purchased for about \$1,500.

*Mutton stearin* and *mutton oil* may be, and at times are, made from the caul fat of sheep in the same manner as oleo oil and oleo stearin. Mutton stearin has a much higher titer than oleo stearin.

**35. Neatsfoot Oil.**—The method of obtaining neatsfoot oil has already been described. This oil is known in the trade as *pure neatsfoot oil*, *extra-prime neatsfoot oil*, etc.

Another grade of this oil is made of the refuse of the first boiling. This material is technically termed *jelly*. With this jelly is sometimes placed the grease from the catch basins in the beef department of the packing house. Care should be taken, however, not to have too much tallow in this oil, as it will remain solid in the barrel. The jelly and grease are boiled with live steam in open vats for 24 hours. A large excess of water must be added to this material to allow the freed oil to rise through the glue liquor formed by the operation. The resultant oil is more or less dark colored, has a strong smell, and contains, as a rule, a high percentage of free fatty acids. This oil is known as *No. 1 neatsfoot oil*.

While packing houses make this oil as described, in the oil trade, neatsfoot oil may mean a different kind from the packing-house oil. An oil made of the "fleshings" of the tannery and of other tannery greases is also called neatsfoot oil. As this oil differs in quality, it is sold on maker's brand, on sample, etc.

**36. Winter-Pressed Neatsfoot Oil and Neatsfoot Stearin.**—To press neatsfoot oil into winter-pressed oil and neatsfoot stearin, it is necessary to have the oil in a grainy condition. By this is meant a separation of the olein from the stearin—the solid portion of the oil. The pure

neatsfoot oil, in barrels, is placed in a room having a temperature of about 32° F. and kept there for 4 weeks. Various unsuccessful methods have been tried to shorten this time. It is customary to set the barrels on end, with one head removed.

After the oil has obtained the condition for pressing, it is placed in cloths of closely woven duck. The cloths when folded contain about 5 pounds of material. In pressing this oil, a double cloth for infolding the material must be used, or an oil of high cold test will not be obtained. The temperature of the press room should be kept steady, at 28° to 30° F., when the pressed oil, using double cloths, will have a cold test as low as 14° to 16° F. The manufacturers, however, will seldom guarantee winter-pressed neatsfoot oil to withstand a cold test under 20° F., owing to the variable and uncertain methods of making the cold test by purchasers.

**37. Pressing of Neatsfoot Oil.**—The details of pressing neatsfoot oil are as follows: The cloths are placed on an upright wooden mold made so that the cloths, when folded, form a bag about 9 in.  $\times$  6 in.  $\times$  1½ in. These bags are placed on the bottom of the press, Fig. 5, with room between them to allow for the spread in pressing. A plate of sheet iron is then placed on these, thus forming another bottom for making the second tier of bags. This operation is repeated until the press is filled with layers of bags alternating with the separating plates of iron. The top plate *b* is usually of wood strong enough to withstand the pressure without bending, thus keeping a flat surface and an equal pressure on the top layer. The chains attached to the ratchet *h* are then connected to the bar *c* on both sides by means of iron links.

The slack in the chains is taken up by raising and lowering the lever *k* until the lever remains raised in the air. The framework *a*, *a* of the press is made of strong angle iron, in which the plates fit easily at the corners, so that they can follow down the pressed bags of oil. The lever *k*, at first

without weights, is raised as soon as it falls to the floor. When the resistance offered by the material in the bags keeps it from falling, a cast-iron weight  $m$  is placed on one of the notches in the lever, and the lever thus weighted is again raised as fast as it falls to the floor. When the lever remains suspended with one weight, another weight  $m'$  is added, and the same performance

until, with both weights the lever remains in the air. The material in the bags during this process is being constantly pressed out of the liquid portion, and is forced to the reservoir through the pan  $f$ . This oil is of low cold test, not much above  $14^{\circ}$  F. The cold test of the oil above this can be regulated by the temperature of the press room, neither practicable nor desirable to produce oil that will have a lower cold test than is mentioned.

The time required to complete the pressing is about 3 days, the process proceeding very slowly until the bulk of the oil has oozed out. The lever must be frequently raised during the first day, and thereafter about twice every 24 hours.

FIG. 5

The form of press shown in Fig. 4 is also extensively employed in pressing neatsfoot oil and greases and may be used to advantage where circumstances permit.

38. The material remaining after pressing is actually *neatsfoot stearin*, but it is seldom sold as such. The close

approach in its nature, composition, and cold test to tallow oil makes its sale as that commodity legitimate. In warm weather, neatsfoot stearin may be sold for neatsfoot oil, since the cold test at this season is not important. This stearin may also be returned to the ordinary neatsfoot oil, where the cold test is not essential.

The bags, or cloths, are shaken free from the pressed material, when they are ready for use again without washing. Cloths for pressing neatsfoot oil may be used four or five times without washing, but the texture is gradually closed up by wax-like stearin, thus necessitating removal. The neatsfoot stearin is simply melted and either barreled for neatsfoot oil or used and sold for tallow oil.

Winter-pressed neatsfoot oil is extensively employed as a lubricant for very fine instruments. The pressed oil is usually heated to eliminate accumulated moisture, and is filtered to remove extraneous contaminations and any accidental dirt. The pressed oil may be, but seldom is, bleached white by means of fullers' earth. The sale for this class of oil is very limited. The process of bleaching is in every way similar to the bleaching of lard, which has already been described.

**39. Lard Oils.**—Lard and grease are used for making lard oils, the operations being carried out in the same kind of presses that are used for pressing neatsfoot oil. The press shown in Fig. 4 is the more modern style and gives quicker results. While the form of press shown in Fig. 5 is largely used, it is being replaced wherever possible by the knuckle-joint press. In large establishments, several of these presses, Fig. 5, are arranged side by side, the pan *f* being made sufficiently long to accommodate all the presses. One outlet *g* serves to drain the oil from all the presses. The axles of the presses are placed at such an angle that the levers clear themselves in falling. The advantage of arranging several presses in this way is that while one press is having the material pressed, another may be filled. As it requires from 2 to 3 days to press oil out of lard and grease, the advantage of such an arrangement is obvious.

**40. Pressing of Lard Oils.**—The same method as that just described is used for pressing lard and greases. Much greater care, however, is required in handling the lard, both before and after pressing, than is necessary with greases or the ordinary lard oils.

The lard is made into a grainy condition suitable for pressing. The more marked and complete the separation of the olein and stearin of the lard, the better and easier it can be pressed. Lard or grease that has not been made into a grainy condition is not susceptible of pressing, as the oil and stearin, being intimately mixed and in a smooth, plastic condition, resist separation by pressure. To obtain the material in the requisite form, the lard or grease, after being filled into the receptacles in a molten condition, is allowed to remain quiet for 3 or 4 days in a temperature of about 60° F., when the separation of the material takes place. A longer period of graining will do no harm, and at times is a positive advantage, as under favorable conditions a most complete separation of the oil and stearin ensues, enabling the lard oil to be dipped from the stearin almost completely. Many small concerns are thus in a position to obtain oil and stearin without the use of a press. This, however, is not a general way of obtaining the lard oils.

The grainy lard or grease is filled into cloths, similar to the manner of pressing neatsfoot and oleo oils and is placed in the press layer on layer until the press is filled as high with material and plates as practicable. The process is similar to that of pressing neatsfoot oil. With lard and grease, a single cloth is sufficient to permit the lard oils to flow through and at the same time retain all the stearin in the cloths.

**41. Winter-Strained Lard Oil (Prime Lard Oil).** In pressing prime steam lard, the material from which winter-strained lard oil is made, the most scrupulous cleanliness is observed, as the resultant lard stearin must fulfil the same conditions as the lard itself. In other words, this oil must have a sweet, mild smell, a clear, natural

whiteness, and be free from all objectionable features. The merchantable titer of lard stearin must be at least 44° C. This necessitates pressing in a temperature of 55° F., and the temperature should not vary more than 2° or 3° either way. Prime steam lard should remain in the press about 2 to 3 days, the lever being raised and weights attached thereto, as occasion demands. Winter-strained lard oil, to pass requirements, should not contain over 2 per cent. of free fatty acids and should possess a mild, sweet smell.

**42. Off-Prime Lard Oil.**—The oil intermediate between prime lard oil and extra No. 1 lard oil is called **off-prime lard oil**. This oil is what its name implies—not quite equal to the prime oil in color, odor, or other characteristics, and yet too high in quality to be classed as the next lower grade. This oil is made like the winter-strained or prime lard oil in all particulars.

**43. Extra No. 1 Lard Oil.**—The grade between off-prime lard oil and No. 1 lard oil is known as **extra No. 1 lard oil**, and while not answering the requirements of the former, it is in every way superior to the latter. Extra No. 1 lard oil is made of material not suitable for the best grade of lard oil and much too good for poor grades. Pig's-foot lard, old or unmerchantable steam or kettle lard, B white grease, etc. furnish material for this oil. In color, extra No. 1 lard oil is generally whitish or very light yellow. It contains a variable percentage of free fatty acids, not, however, exceeding 5 or 6 per cent., and is usually of mild odor. If this oil is rather dark in color, the custom is to bleach it as light as possible, by the usual method, with fullers' earth.

**44. No. 1 Lard Oil.**—The next lower grade of lard oil is called **No. 1 lard oil**. This oil is made of light-colored grease and is ordinarily bleached as light as possible by means of fullers' earth; the lighter the oil, the better is the price obtained. Although light-colored grease is preferable for this oil, any material of this nature susceptible of after bleach may be used. A very small amount of dark, unbleachable grease will discolor many times its own volume

of light-colored grease; this is also true of oils. From this it will be seen that the grade of dark-colored oils or any other fatty material cannot very well be raised by mixing with them light-colored material of the same kind. No. 1 lard oil has a more or less rank odor. The free fatty acids should not exceed 15 per cent. This latter quality is exceedingly variable, and other things being equal, the preference in sales is given to oil containing the least amount of free fatty acids.

This grade of oil is extensively made and is used almost exclusively for lubricating machinery and for mixing with mineral lubricating oils. At times, when the price permits, it is also used industrially in woolen mills, etc. The requirements as to cold test, etc. will be found in the annexed rules governing the transactions in animal oils in the New York Produce Exchange.

**45. No. 2 Lard Oil.**—The grade known as No. 2 lard oil has of late years fallen into much disfavor, owing to its replacement by the less expensive mineral oils. It is not manufactured very extensively at the present time on account of its limited sale. No. 2 lard oil is made of brown grease—the refuse grease of the packing house. The pressing is carried out in the usual manner, not much care or attention, however, being given to the cold test. The color of this oil is usually a dark, reddish-black, but there are no requirements asked or expected in reference to color or free fatty acids. The latter may run as high as 30 per cent. As a rule, the free fatty acids range from 18 to 24 per cent. This oil is always sold on sample, and is used industrially in woolen and carpet mills to a certain extent.

For obvious reasons, it is always the rule in pressing greases to grade them so that they will produce the highest grade of oils possible. The usual yields of oil and stearin from pressing greases is 45 per cent. of stearin and 55 per cent. of oil, but this is varied according to market conditions.

**46. Bleaching Requirements of the Several Grades of Lard Oils.**—All the oils after pressing are allowed to

settle in the receiving tanks until a sufficiently large quantity has accumulated to filter and, if necessary, to bleach. The oil is placed in the bleaching tank, the air blower started, and the oil heated and agitated until the temperature reaches 160° F., when the necessary quantity of fullers' earth is added and the hot oil and suspended clay are pumped through the filter press. The bleached and filtered oil is sent to the storage tanks, from which, after the oil has been allowed to cool to normal temperature, it is drawn into the regulation oil barrels. It is necessary to allow hot oil to cool before filling the barrels. This is done so that the oil will not acquire cloudiness in the barrels while cooling. Such oil is technically termed *off*.

*Winter-strained lard oil* is never bleached, but simply mildly heated and settled, to eliminate the moisture present, and passed through the filter press, to remove extraneous impurities and all traces of moisture.

*Off-prime lard oil* is treated in the same manner as winter-strained lard oil.

*Extra No. 1 lard oil*, if not sufficiently whitish in color, is treated with the required amount of clay to produce the light color and passed through the filter press.

*No. 1 lard oil* may or may not require bleaching, depending on the grade of material used in its pressing. For some trade, however, it is always bleached, the lightest possible color being desired.

*No. 2 lard oil* is never bleached; it is simply settled to clarify, and heated to expel moisture. This oil is seldom filtered through the press, clarification by subsidence generally being sufficient.

**47. Lard and Grease Stearins.**—After the oil has been pressed from the material, the stearin remaining is shaken free from the press cloths, and when a sufficient quantity of it has accumulated, it is melted, mixed to insure uniformity, and run into tierces.

*Lard stearin* is used to stiffen refined and mixed lards, thereby causing such lards to withstand warm weather with-



out melting. At times, though very seldom, this stearin is used in lard compound.

*Grease stearins* are divided into several grades corresponding to the greases from which they are made. That from grade A white grease is branded *white-grease stearin* and is used by soap manufacturers. The stearins from grade B white and yellow grease are both classed as *yellow-grease stearin*, no distinction being made between them. This stearin is used almost exclusively in soap manufacture, having a titer somewhat higher than the usual trade tallow; large quantities are also exported. *Brown-grease stearin* is seldom met with in trade, it usually, and then very rarely, being made on order in the packing houses. This material is used for distilling into olein and stearin and at times for soap making.

The requirements of stearins are limited to the titer, or hardness, and the amount of moisture and impurities they contain. The titer required of lard stearin must be at least 44° C., and it must not contain over 1 per cent. of moisture nor any impurities. White-grease stearin, as well as yellow-grease stearin, is sold at a price corresponding to its hardness and the amount of moisture and impurities it contains. These stearins are usually pressed to a hardness of 43° or 44° C., and contain, as a rule, less than 2 per cent. of moisture and impurities combined. The rapid methods of determining these, as practiced in packing-house laboratories and at the present day by many tallow and grease brokers, will be given later.

**48. Tallow Oil.**—With the exception of modifications as to temperature in pressing, tallow oil is made similarly to lard oils. Like lard and grease, the tallow must be in a *grainy* condition before it can be successfully pressed; and, similarly, the better the separation of the olein from the stearin in the *seeding* receptacles, the quicker and better the separation of the oil in the press.

The molten tallow for pressing is drawn into suitable receptacles, such as open-headed barrels or trucks, and

allowed to stand for 5 days at a temperature of from 75° to 85° F. The tallow by this time will have resolved itself into the components of oil and stearin, and is ready for pressing. It is unwise to allow the grained tallow to remain without pressing longer than this period, as the stearin grains will constantly increase in size, entangling the olein, in consequence of which it will be very difficult to press out the required yield of oil.

**49. Pressing and Bleaching Tallow Oil.**—The grained tallow is manipulated in the same manner as grease, and when made ready in the cloths for pressing, it is filled into the molds in the way already described. The cakes are placed in the press, Fig. 4 or Fig. 5, and the operation is completed in the usual way. The tallow is pressed for 2 or 3 days at a temperature of about 85° to 90° F. The higher the temperature of the press room, the greater will be the yield of tallow oil; but, on the other hand, the cold test of the oil will be quite high, owing to the greater quantity of stearin melted into the oil. This procedure of pressing at a high temperature is practiced at times when the price of the oil is higher than that of the tallow stearin. The usual yield, however, is from 45 to 50 per cent. of oil from the tallow.

The oil is conducted to a reservoir until a sufficient amount has collected for filtering and, if necessary, for bleaching. Tallow oil is ordinarily of a very light yellow or white color. If the pressed-out oil is satisfactory in color, it is bleached in the usual manner, from 3 to 6 per cent. of fullers' earth, depending on the stock, being employed. The temperature at which the material is bleached is of no particular consequence, as this oil is not used for food purposes. A good temperature is around 140° F. The oil need not be bleached to a water-white color, as this is not an essential. This oil is used in compounding with mineral lubricating oils.

**50. Acidless Tallow Oil.**—The first step in procuring acidless tallow oil is to obtain the ordinary tallow oil as just described. In selecting tallow for this purpose, it

should not exceed 4 or 5 per cent. of free fatty acids, as, when pressed, these free fatty acids are practically doubled in their relative percentages in the pressed oil, the material left in the cloths—tallow stearin—retaining a very small part of them. The less free acid a tallow contains, the less shrinkage there will be in the operation of making into the acidless condition. The operation is carried out in the following manner:

The oil is brought into the treating tank, which is similar to the bleaching tank shown at *A*, Fig. 5, *Packing-House Industries*, Part 1, and may be used as such, the suitable connections being provided. This tank must have the cock *m* about 4 or 5 inches wide, in order that the soap formed may be withdrawn through it. The other attachments of this tank are the same as for the regular bleaching tank. The oil is brought to a temperature of from 125° to 135° F., and the percentage of free fatty acids having been previously ascertained, sufficient solution of caustic soda is added to combine with the free fatty acids present. The caustic solution is made with a strength of 20° Baumé, as this strength has been found best for this purpose. During the addition of the alkali, the oil is constantly agitated with the air blower.

In a few minutes the reaction is complete, when the oil is allowed to stand at rest for 5 minutes, to allow the soap formed by the combination of the alkali and the fatty acids to collect on top of the oil. A portion of the soap will sink to the bottom with the excess of water. The floating soap is removed by skimming, and the soap in the bottom of the tank is removed, together with the water, through the cock *m*. The oil is then agitated, to cause the remaining soap to gather together. This soap is also removed in the same manner, and the oil is now washed with clean water and agitated strongly with the air blower. This washing serves to remove the last traces of soap and any excess of alkali present. The wash water is then drawn off, and the oil is heated to 165° or 170° F. and blown until the last traces of moisture have been removed. The oil is now ready for bleaching and filtering, which are carried out in the usual

manner. Acidless tallow oil is always bleached after being made acidless, and, as mentioned before, the same tank may be made to serve for the complete operation.

**51.** The chief trade requirement of acidless tallow oil is that it shall contain not more than  $\frac{1}{2}$  per cent. of free fatty acids. The cold test of this oil is of no material importance, although it is generally made to stand a test of about 45° F. The whiter the color, the more acceptable the oil, other conditions being equal.

Acidless tallow oil finds its greatest use in compounding with mineral lubricating oils, where the absence of all acidity is of the highest importance. It is also used alone as a lubricant for machinery. This oil, as made in the large packing houses, seldom contains over .2 per cent. of free fatty acids. The soap formed in the manufacture of acidless tallow oil, when a sufficiently large quantity has accumulated, is decomposed with sulphuric acid of 66° Baumé in a lead-lined tank. The resulting fatty acids, black in color, may be mixed, if desired, in small quantities at a time with No. 2 tallow.

**52. Tallow Stearin.**—The material remaining in the cloths in the press after the oil has been pressed out of the tallow is **tallow stearin**, corresponding to the grease stearin resulting from the operation of pressing grease. The tallow stearin is shaken free from the cloths, melted, and run into barrels or tierces while warm. The hardness of this material depends on the quality of the stock from which it is derived and also on the amount of pressure to which the tallow is subjected. In general, it will have a titer of 46° or 47° C. This material, like tallow, is purchased on the result of the titer test. Tallow stearin finds utility in the currying and finishing of leather and in the candle industry, and at times is used in the manufacture of high-grade soaps.

**53. Bleached Tallow Stearin.**—In order to obtain **bleached tallow stearin**, it is simply necessary to bleach the foregoing product to a white color with the required amount of fullers' earth. The bleaching is done in the usual manner, no notable quantity of fullers' earth being required

to produce the desired white bleach. The industrial uses of this product are the same as for the ordinary tallow stearin. Tallow stearin is not usually bleached unless required for special trade; it is then always sold at a corresponding advance in price.

**54. Bleaching of Oils.**—The bleaching of oils is carried out in the same manner as that of lard. With lard and tallow oils, however, the process need not be so carefully conducted as to temperature, etc.

The temperature required for obtaining the requisite bleach in oils is higher than that required for lard and tallows. But here, also, the lower the degree of heat at which the oils may be made to bleach, the better will be the odor of the product. As these oils are not used for food purposes, the taste and odor are not of so much importance as with lard, and the use of an excess of fullers' earth in bleaching is not so closely observed except as a matter of cost.

The quantity of fullers' earth necessary to bleach a given oil varies with the nature of the material. While one oil will bleach with 2 or 3 per cent. of fullers' earth, another similar oil may require 7 or 8 per cent. When more than the latter quantity is necessary, as shown by preliminary tests, bleaching is not attempted, as the enhanced value of the bleached oil would not equal the cost of the labor and fullers' earth used in the operation.

**55. Bleaching Test.**—The oils may be tested for the amount of fullers' earth necessary to bleach by taking an ordinary 4-ounce, oil-sample bottle and weighing in 100 grams of the oil under consideration. The percentage of fullers' earth judged necessary to effect the bleach is weighed off and then added to the hot oil in the bottle. By placing the oil and bottle in a steam bath for several minutes previous to adding the fullers' earth, a temperature closely approximating that obtained in the bleaching tank is obtained. If necessary, the temperature of the oil, which must be at least 170° F., may be tested with a thermometer.

After adding the fullers' earth, the bottle is closed and violently shaken for 3 or 4 minutes to effect the bleach. The mixture is then poured on a filter paper placed in a hot funnel, and the color of the filtered oil observed. If not satisfactory, another test is made, using a larger quantity of fullers' earth. In this way, the amount necessary for the quantity of oil can be determined before starting to bleach. It should be remembered, however, that this test is crude and only comparative, as the conditions are not the same in the bottle as in the bleaching tank with the air-blower agitation. An oil will always be bleached in the tank with a smaller quantity of fullers' earth—approximately from 1 to  $1\frac{1}{2}$  per cent. less—owing to the better agitation and more intimate and continuous contact between the fullers' earth and the oil.

**56.** In bleaching oils, the same precaution as with lard must be observed—that is, to have all moisture eliminated before adding fullers' earth—or no bleach will be obtained. After the bleached oil oozes from the filter press in a bright, sparkling condition, unlike lard, it is run to a cooler, or tank, where it is allowed to cool to room temperature before being drawn into barrels.

The apparatus shown in Fig. 5, *Packing-House Industries*, Part 1, is used in the bleaching of oils. After low-grade oils have passed through the apparatus, everything with which it has come in contact must be thoroughly cleaned, so as to remove all traces of free acid and odor.

**57. Tests on Pressing Oils.**—The results of a test on pressing extra-prime, or pure, neatsfoot oil follow. The oil was pressed into winter-pressed neatsfoot oil. The test shows how the cost of transforming one product into another is figured in the packing house, every detail being taken into consideration. The prices given are the ones that prevailed at the time. It is always customary to figure the value of oils *loose*, that is, not in barrels, at 2 cents per gallon less than when sold in these packages, this difference in price being ordinarily the cost of a 50-gallon oil barrel. This

price, however, follows the prevailing market value of the package. The tests are based on 100 pounds of material.

100 pounds of extra-prime neatsfoot oil yielded:

	POUNDS
Neatsfoot stearin . . . . .	54.5
Winter-pressed neatsfoot oil . . . . .	44.5
Loss . . . . .	1.0
Total . . . . .	<u>100.0</u>

100 pounds of extra-prime neatsfoot oil, loose, cost (sale value) . . . . .	\$7.06
Labor for 100 pounds of material . . . . .	.20
	<u>\$7.26</u>

Value of $54\frac{1}{2}$ pounds of neatsfoot stearin, at 6 cents . . . . .	<u>3.27</u>
Net cost of $44\frac{1}{2}$ pounds of winter-pressed neatsfoot oil . . . . .	\$3.99

1 pound of oil costs . . . . .	\$.0896
1 gallon of pressed oil ( $7\frac{1}{2}$ pounds), loose, costs . . . . .	.6720
1 gallon of pressed oil ( $7\frac{1}{2}$ pounds), in barrel, costs . . . . .	.6920

Thus, the actual cost to the manufacturer of making 1 gallon of winter-pressed, pure neatsfoot oil is in this case, at the prices given, 69.2 cents.

A test on pressing tallow into oil and tallow stearin gave the following results:

100 pounds of tallow, at a labor cost of 36 cents per hundred pounds for all operations, yielded:

	POUNDS
Tallow oil . . . . .	50
Tallow stearin . . . . .	49
Loss . . . . .	1
Total . . . . .	<u>100</u>

. Butter-stock tallow when pressed yields a much larger quantity of tallow oil, owing to the small amount of stearin present in comparison with the olein. A test made on this material gave for

100 pounds of butter-stock tallow:

	POUNDS
Tallow oil . . . . .	72
Tallow stearin . . . . .	27
Loss . . . . .	1
Total . . . . .	100

In figuring oil-pressing tests in the packing house, it is always customary, even if the actual weights show that no losses have occurred, to estimate pressing losses as 1 per cent. This loss may at times be exceeded. If this is the case, the actual loss must be figured in to obtain the true results.

**58. Rules Regulating Transactions in Oil.**—The following are excerpts from the rules regulating transactions in oil (other than petroleum and cottonseed oil) among members of the New York Produce Exchange:

**RULE 3.**—All lard oil shall be tested by the following method: The oil to be tested shall be taken from at least one-quarter of the barrels sold or delivered, and when well mixed together, shall be placed in a glass bottle such as is now used to test the specific gravity of paraffin and other oils, and shall not be over 4 or under 2 inches in diameter, nor over 10 or under 6 inches in height. The thermometer shall be placed in the oil, and when it indicates the degree to be tested at, it must not be allowed to go more than 1° below or 1° above that point. After remaining 4 hours, if the oil shows no evidence of congealing, it shall constitute a good delivery.

**RULE 4.**—Tares shall be tested, if required by either buyer or seller, by emptying 5 barrels in each 100 barrels to be taken indiscriminately from the lot.

**ANIMAL OILS**

**RULE 5.**—Prime lard oil shall be bright and sweet, and shall have the flavor of good sound lard. Whiteness with lack of flavor, or any indication of rancidity, shall not constitute prime or contract oil. All animal oils shall be sold by weight, at the rate of seven and one-half (7½) pounds net to the gallon.

**RULE 6.**—The winter test of lard oils of all grades shall be 43° F. or under. The spring and fall test of lard oils of all grades shall be 55° F. or under. The summer test of lard oils of all grades shall be 65° F. or under.



**RULE 7.**—All contract oil must be in good, sound, iron-bound barrels, holding not less than 42 nor more than 50 gallons. In settling contracts without delivery, the basis shall be 46 gallons per barrel.

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### **BEEF EXTRACT**

**59.** In the making of beef extract in the packing house, the product of beef only is used. Beef extract is a very profitable product, as in most cases waste liquors, washings, and waters from the boiling of meat, which are practically without value for other purposes, can be used to advantage.

The manufacture of meat extract as carried on in the packing houses and the meat-canning establishments of the United States is merely a side issue, and comprises essentially only the concentration of suitable meat juices to a proper consistency. Only on rare occasions is fresh meat used especially for meat-extract purposes, and even then it is only head meat or cheek meat, hearts, and other cheap meats, and these only when sausage meat is a drug on the market.

For a short period, some packers that make sausages on a large scale thought it profitable to soak all their sausage meat thoroughly, press the juice from the meat, and use this juice for meat extract. While they found this profitable for the extract department, it was greatly to the detriment of the sausage department. Sausages made of such extracted meat have a very flat taste and no keeping qualities.

The waters in which fresh meats have been soaked (the so-called *cellar waters*), the waters from the cooking or scalding of meats for canning, and certain bone liquors, hereafter described, constitute the main sources of beef extract. The entire manufacture from such liquors is quite simple and relatively inexpensive, the cost being practically the labor and steam employed. Figs. 6 and 7 illustrate the apparatus used in the manufacture and show the principle of the operations.

**60.** The system of making meat extract by soaking the fresh meat with a relatively small amount of water and then pressing the juice from the meat with powerful hydraulic

presses, is operated in the United States by only one small concern to a very limited extent. If prepared with the greatest care, a great deal of skill and experience, and in the very best obtainable vacuum (of about 29 inches barometric pressure, at a temperature below 120° F.), requiring a special and expensive vacuum pan, this meat-juice extract represents a very superior article and brings a high price, but the market

FIG. 6

is very limited, and the one small factory in the United States finds it difficult to sell its product. This process is too expensive to be employed in the ordinary meat-canning or packing establishments.

**61. Process of Manufacture of Beef Extract.**—The method of manufacturing beef extract from meat liquors, etc. is carried out in the following manner:

The scalding liquors (soup waters) from the cook room of the canning department, bone liquors, etc. are pumped into the wooden vat *A*, Fig. 6, which is about 2 feet high and of suitable length and width to hold 1 day's soup liquors, etc. Instead of using one very large tank, it is advisable to use two or three smaller ones. The tank or tanks are provided with 1-inch steam pipes that are placed sufficiently far apart to permit the pipes and the bottom of the vat beneath them to be readily cleaned. The tanks are slightly inclined toward one corner, to facilitate complete draining and washing out.

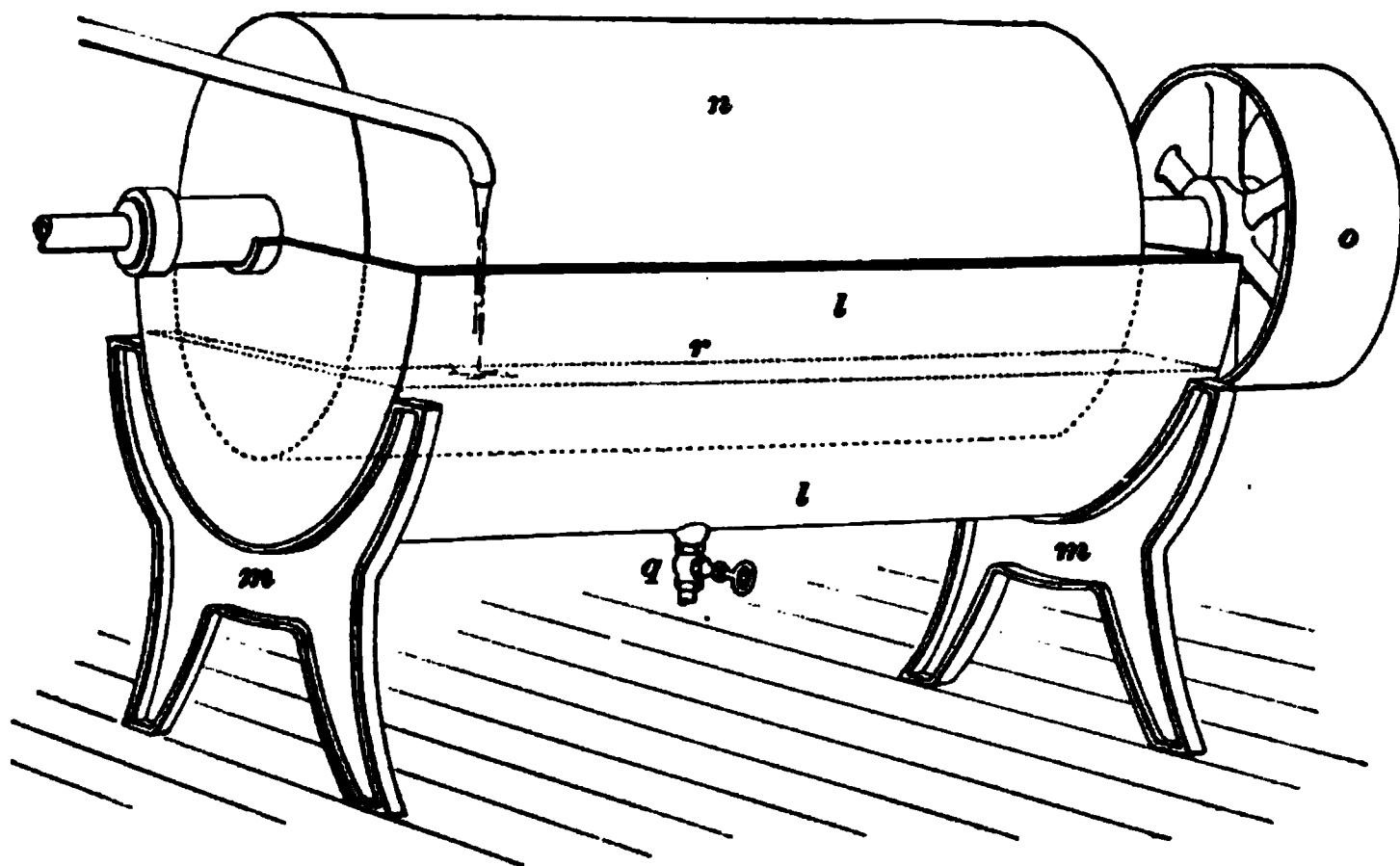


FIG. 7

The soup liquors and bone liquors are boiled down in tank *A* to about one-half or one-third their original volume. Then an equal volume (or thereabouts) of cellar water (from the soaking of fresh meat) is pumped into the soup water. By continued heating of the mixture, the albumin in the cellar water is coagulated, and while coagulating envelops all the suspended impurities. Steam is turned off and the liquor is allowed to settle. The amber-colored clear liquor is drawn from vat *A* through cock *c* and the hair sieve *d* into the vat *B*, which is arranged similar to vat *A*. In vat *B*,

the liquor is further concentrated to a density of about 7° or 8° Baumé. If the liquor shows any tendency to become cloudy or off-colored, a little more cellar water is added to it, thus producing a second coagulation and clarification of the liquor. Steam is then shut off from vat *B* and the liquor is drawn through cock *e* and the valves *f* into filter bags *g*. These bags are made of cotton flannel (about 15 inches square on top and 2 feet deep) and are suspended by hangers *h* from a suitable rack. The gutter *j* catches the clear, filtered liquor and conveys it to the rotary evaporator.

**62.** The rotary evaporator, Fig. 7, consists of a steam-heated, revolving drum *n* that is driven by a belt from the pulley *o*. This drum, which is about 3 feet in diameter and from 5 to 10 feet long, revolves in a trough *l* that is supported by the legs *m*. At the back of the steam-heated roller *n* and at its side, are arranged scrapers, which serve to keep the surface clean. In addition, the entire roller is supported in a frame that permits the raising and lowering of the roller, according to the amount of liquor present.

The amount of liquor in the trough *l* is so regulated that the drum *n* dips into it only to about the depth shown by the dotted line *r*. The steam drum is so constructed as to withstand a considerable boiler pressure, but it is usually run with not more than a pressure of 20 pounds per square inch, and very frequently with less. In its revolutions (about 25 to 40 per minute), the drum carries sufficient liquor on its surface to prevent complete drying and burning. When the desired density is reached, which is about 20° Baumé for the fluid extract and 32° Baumé for the so-called solid, or paste, extract, the concentrated liquor is drawn through cock *q* or dipped over the edge of the trough *l* into suitable receptacles, from which it is filled into bottles or jars. Such is the principle of the most simple and inexpensive and yet convenient meat-extract apparatus in operation.

**63.** However, simply because better evaporators are offered in the different multiple-effect evaporators, the larger packing houses and many others have abandoned the use of roller evaporators. But these multiple-effect evaporators are only suitable for operations on a large scale, when from 10,000 to 50,000 gallons of meat liquors is concentrated in 24 hours. For a small concern, the labor and attention demanded by these evaporators require too great an expenditure, and thus overcome their principal advantage—the saving in fuel.

A rotary evaporator will evaporate, for each pound of steam delivered to the apparatus, about  $1\frac{1}{2}$  to  $1\frac{1}{4}$  pounds of water, thus getting an evaporation of about 10 pounds of water from each pound of coal. The average double-effect evaporators give 16 pounds of water evaporation for each pound of coal of the same class; the triple-effect evaporators give 24 pounds of evaporation. The rotary evaporator is very suitable for the concentration of tank liquors or tank waters on a small scale, and is used for this purpose by some packers.

**64. Soup Liquors and Rib Bones.**—For making meat extract, all the cooking and scalding waters of fresh meats and of mildly cured salt meats can be used, and mixed with them is a small quantity of corned-beef soup water. The scalding water of strongly pickled meats used alone gives an extract that is too salty and of a strong, pungent odor and taste, due to the saltpeter contained in it. All the cellar waters ("soak" waters from fresh meat) can be used if they are sweet and in sound condition.

All canning bones, that is, bones from meats cut for canning, thigh bones, etc., give, when heated for an hour or two with lukewarm water (about 125° F.), a bone liquor that is extremely well adapted as an addition to the soup liquors in the manufacture of meat extracts. Care must be taken, however, not to use the water too long or too hot on the bones, as in such a case the liquor will dissolve too much gelatine and give to the meat extract a gluey flavor. For

the same reasons, bone liquors alone do not make meat extract, but when blended with soup liquors and cellar waters, an excellent beef extract results.

Where large quantities of cheap meat are available for beef-extract purposes, such, for example, as hearts, cheek meat, etc., the meat is cut into small pieces—about 1-inch cubes or thereabouts. This meat is then soaked in ice-cold water for 24 hours, the mass being frequently stirred with forks. After 24 hours, the first water is drawn off and pumped into tank *A*, Fig. 6. Then a second quantity of water is put on for another 24 hours, this water also being sent to tank *A*. In former times, hydrochloric acid in the proportion of 1 gallon of acid to 250 gallons of water was added to this water so as to get a better yield; but, according to a decision of the Secretary of Agriculture, hydrochloric acid can no longer be used in the manufacture of meat extract.

The cold, extracted meat is then sent to the cook room, where it is cooked for from 3 to 4 hours in the scalding tubs, or for 2 hours at a steam pressure of 20 pounds per square inch, in iron digesters. The residue of this cooking either goes into the tankage or is occasionally sold for dog biscuit and other similar purposes; at times it is worked into mince meat.

**65.** All the apparatus used in the manufacture of meat extract must be thoroughly cleaned every day. The tanks *A* and *B*, Fig. 6, must also be kept scrupulously clean, not only at the sides and bottoms, but especially around the steam pipes. Occasional boiling with soda-ash solution will clean these vats perfectly. The coagulum from these vats, which collects in the sieve *d* and the filter bags, finds proper use in the tankage. The filter bags must be thoroughly cleaned with hot water after each day's use. Occasionally, it happens that the liquid in the rotary evaporator turns cloudy, due to imperfect previous clarification. In such cases, the liquid is conveyed into a steam-jacketed open kettle, where either fresh cellar water or defebrinated blood is added and the

mass brought to a boil, producing a new coagulation; then by filtration through the bags a perfect clarification of the material is obtained.

**66. Forms of Extract.**—Beef extract is put on the market in two forms, either as *fluid extract* or as *paste extract*, according to the degree of concentration.

**67. Fluid extract** is concentrated to a density of about 29° to 32° Baumé, and contains from 42 to 48 per cent. of moisture. As a rule, there is an extra amount of common salt added, so as to bring the percentage of salt up to 10 per cent. This requires usually from 2 to 4 per cent., as the meat from which the extract is made furnishes from 6 to 8 per cent. of salt. The extra amount of salt in the fluid extract is necessary to give it better keeping qualities, as no antiseptics or preservatives are ever used in beef extracts. Fluid extract is usually put up for the trade in glass-stoppered bottles; large quantities, for storing, etc., are put up in square, 14-pound, meat-canning tins, the cans being processed in dry steam for 1½ hours at a pressure of 10 pounds per square inch.

**68. Paste extract** is boiled down to a concentration so that the product contains from 20 to 24 per cent. of moisture; it then contains from 55 to 65 per cent. of organic substances and from 15 to 20 per cent. of salt. Paste extract is usually put up for the trade in porcelain or milky-glass jars; but to store or ship in large quantities, it is put up in square, 14-pound cans and capped without any processing.

Fresh meat, such as roast beef, etc., prepared for canning purposes in the regular way yields about 1 pound of paste extract from 60 pounds of meat (from soup water and cellar water). By longer scalding in the preparation for canning, the yield can be raised to 1 pound of paste extract from 40 pounds of meat. If the meat is treated only for extract, that is, if the meat is finely cut, soaked for 24 hours, and cooked to thorough disintegration during 3 or 4 hours, the yield will be about 1 pound of paste extract from 25 to

30 pounds of meat. Bone liquors give  $\frac{1}{4}$  to  $\frac{1}{2}$  per cent. of paste from the amount of bones soaked in warm water.

The labor in the beef-extract department (exclusive of the label room) does not amount to much, one man and a helper being able to produce large quantities of extract.

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### MEAT CANNING

**69.** The hermetic sealing of food, usually referred to as **canning**, is an industry that has grown to be an important factor in the commercial and industrial development of the United States. This industry has long since passed the experimental stage, and has taken its place among the leading industries of the country.

The process used in the canning of meats is what is known as the *Appert process*, which was invented in 1809. Although this process has been well known to scientists for the entire period since its invention, its commercial application has been made available only a comparatively few years. Up to the present time, nothing has been discovered to supersede this universally applied process for the preservation of meats and of vegetables in cans.

**70.** Prior to 1795, drying and the use of salt and sugar were the only methods used to any extent in the preservation of foods. At this time, Nicholas Appert, a Frenchman, who had spent most of his life in the preparation and preservation of articles of food, being stimulated in his work by the offer of a reward by the French Navy Department for a method of preservation of foods for sea service, submitted to his government an exhaustive treatise bearing on the hermetic sealing of all kinds of food. His method was to enclose fruit in a glass jar, which was then corked and subjected to the action of boiling water for a time, varying according to the nature of the article treated.

A description of his process can best be summed up in his own words, as follows: "It is obvious that this new method of preserving animal and vegetable substances proceeds from



the simple principle of applying heat in a due degree to the several substances after having deprived them as much as possible of all contact with the external air. It might, on the first view of the subject, be thought that a substance, either raw or previously acted on by fire, and afterwards put into hot bottles, might, if a vacuum were made in those bottles and they were completely corked, be preserved equally well with the application of heat in the water bath. This would be an error, for all trials I have made convince me that the absolute privation of the contact of external air (the internal air being rendered of no effect by the action of heat) and the application of heat by means of the water bath, are both indispensable to the complete preservation of alimentary substances."

As before mentioned, time has proved Appert's method to be the most satisfactory for preserving food in its natural state.

**71.** Glass jars, which were originally used for this purpose, were gradually abandoned, as it was found that they could not withstand the extremes of temperatures, and that they were expensive, bulky, and costly in transportation. Although glass jars are used to some extent at the present day for the preserving of vegetables, fruit, etc., tin cans are universally employed for the canning of meat.

The objection having been urged against the use of tin cans that the natural acids of fruits, vegetables, meats, and fish act on the tin and solder in such a way as to form metallic salts or metallic compounds that are injurious to the health, the matter was carefully investigated by expert chemists, who reported that the objection is groundless if good tin is used. In the poorer grades of tin, injurious substances were found, but in such small quantities that they were of no consequence.

The principle underlying the preservation of meat or other edible substances in air-tight cans is that the decay of organic matters is not due alone to oxidation, but to the action of bacteria, organisms, ferments, etc., which attack and act on

the organic substances, decomposing them and resolving them into their original elements or other compounds. The heating of the meat or other material in the process of canning destroys or paralyzes the bacteria and ferments, and the hermetic sealing of the cans prevents bacteria from again entering into the material. Hence, canned goods made of good material and properly prepared remain indefinitely unchanged and in good condition. The process is, in fact, that of sterilization by heat.

**72.** The meat-canning industry, in connection with the packing industry, was started in a small way in Chicago about the year 1877. It was primarily established with a view of saving a large proportion of the meat that up to that time had been either unsalable or of very little value.

The canning industry comprises so many different branches that only the most important features and the general plan and scope followed will be given here.

**73. Selection and Preparation of the Meat.**—The meat selected for canning is ordinarily taken from lean cattle that, while in good, healthy condition, are not suitable for *beef* cattle. Cattle of this kind are known in the trade as *canners*. These animals are slaughtered in a large measure to obtain meat for canning purposes. The parts of the beef that cannot be sold at a profit go to the canning department of the establishment. The portions sold in the fresh state comprise the hind quarters, loins, and, in some cases, salable fore quarters. The fore quarter, however, furnishes the bulk of the meat for canning purposes. One reason for this is that there is less fat on this part of the animal.

The fore quarter is taken to the *boning room*, and the bones are removed entirely from the meat. This meat is cut into pieces of about 5 or 6 pounds each, in order to facilitate curing uniformly throughout when placed in pickle for the making of corned beef. In boning, great care is exercised not to leave any bone in the meat, as even small bones are liable to break the stuffing machine and otherwise cause delay by stopping this machine when the meat is being

stuffed into cans. The small pieces of meat are cured by themselves and mixed with the larger ones when canning.

**74. Curing and Cooking the Meat.**—The meat is cured in a mild pickle, in which are placed small quantities of saltpeter and sugar, the former not exceeding 4 ounces to each 100 pounds of meat, and the latter varying in quantity from 1 to 2 per cent. The meat after remaining in this pickle from 15 to 26 days is cured and ready for boiling or shrinking. After washing in cold water to remove the pickle, the meat is placed into boiling vats. These are wood-end vats that hold, at each charge, about 700 pounds of meat. The time of cooking varies with different meats. For canned *roast beef*, the meat is not subjected to the curing process, but is cooked, while fresh, in

FIG. 8

boiling water for 20 minutes. The cooked meat is then removed and stuffed into cans by the can-stuffing machine, shown in Fig. 8, after the requisite amount has been weighed off. In canning, the meat suffers considerable shrinkage in weight, averaging about 20 per cent. with roast beef.

For cooking *corned beef*, the meat is boiled for 10 minutes, after which it is allowed to stand in the hot water for 1 hour. This method freshens the meat and also causes far less

shrinkage than by another common method of boiling it for 1 hour. The average shrinkage in cooking corned beef is about 38 per cent., although at times it is not more than 30 per cent. The water (soup water) from the cooking or shrinking of meats is used for making soups and also in the manufacture of beef extract.

**75. Canning and Processing.**—When the meat is removed from the cooking tubs, it goes to the cutting table, where it is cut into sizes suitable for the stuffing machine; it is then passed to the weighing table, where the proper amounts are weighed off and fed to the stuffing machine.

FIG. 9

After the cans are stuffed, they are reweighed, wiped, the cap placed over the opening through which the meat was stuffed, and inspected. The cap is soldered on when the can is on the capping machine shown in Fig. 9. The small hole in the center of the cap, the vent, is finally closed with solder, when the can is ready for processing. This may be done either in a water bath or in a retort like that shown in Fig. 10, the retort or steam process being most commonly used.

**76.** The retort shown in Fig. 10 is 28 inches wide, 32 inches high, and 10½ feet long, and will hold at one time 700 three-pound cans, when arranged on the iron trays as shown in the illustration. The retort is provided with steam

connections and a steam gauge for registering the steam pressure. Doors are located at each end and are provided with the usual tightening appliances. There is always a valve controlling the exhaust of the retort, as with some goods and in "boiling off" sealed cans the exhaust has to be kept open. The retort has a perforated steam pipe fastened to the entire length of the bottom, so as to distribute the steam equally throughout the box when processing.

FIG. 10

Different materials are subjected to different pressures of steam and remain in the retort for different periods of time. The size of the cans also influences the time and pressure. As a general average, the cans are subjected to a temperature of about 220° F. for 2 hours.

**77.** The object of processing, as mentioned before, is for complete and thorough sterilization, as well as for additional cooking of the meat. At the expiration of the required time in the retort, the cans are removed on the trays and then, in

order to allow the air in them to escape, they are punctured (the vents opened). This operation is done as quickly as possible, the vents closed up, and the cans returned to the retort and heated again for a shorter or longer time, depending on the size of the can. This latter processing is technically termed *boiling off*.

Processing and boiling off under water with closed vents is also practiced extensively with satisfactory results, and it

FIG. 11

is claimed by some that this method gives a better flavor to the canned product. In processing in the water bath, the time of process is taken from the time the water begins to boil. These process tanks, either of wood or of iron, are 3 feet 10 inches long, 2 feet 10 inches wide, and 3 feet 6 inches deep. The cans are put into the process tanks on trays, to facilitate handling in removing. The cans, when

removed, are also punctured the same as in steam processing, sealed, and boiled off again in the water.

The calcium-chloride bath is also employed for processing and boiling off. A solution of this salt is made with water, which makes possible a temperature of 240° F. in the open bath, whereas the highest temperature obtainable in the ordinary open vat with water is 212° F.

**78.** The cans of meat after removal from the retort or process tanks for the last time are taken to the *shower room*, where cold water is run on them until they are cool. This sudden chilling contracts the ends of the cans, making them slightly concave, which is the proper condition for canned goods. The cans are then sent through a washing trough by mechanical means, to remove any grease or other accumulations. From the washing machine the cans go to the lacquering and labeling room, where they are finished and made ready for packing and shipping.

**79. Soldering Machine.**—For soldering cans under a vacuum, the machine shown in Fig. 11 is employed. The cans are placed in the machine through the door *A*, and a vacuum is then made inside the machine. The machine is then revolved by hand, and the cans are soldered with one turn of the machine. After this operation, the door is opened, and the cans are removed by one more turn of the revolving plate, which is operated by the turning wheel *B*. These vacuum sealing machines are equipped for either electric or gas soldering.

**80. Specifications for the United States Navy.** The specifications for canned beef for the United States Navy show what may be regarded as the requirements in general for canned beef. Specifications are also given for tinned (canned) ham, bacon, and lard.

#### TINNED CORNED BEEF

Shall be of the best quality corned ox beef, full weight, in key-opening tins of 2 pounds each, the weight of the tins not included. Each tin to be marked with the contents, name of contractor, name of packer, brand, and date of packing, and to be properly lacquered.

Each dozen tins to be enclosed in a substantial box made of well-seasoned pine or spruce; sides to be  $\frac{3}{4}$ " and ends 1" thick.

Boxes to be marked on one end with contents, name of contractor, and date of packing, and to be free from all other marks. The contractor shall guarantee that the beef will keep good in any climate for 1 year from date of delivery.

#### **TINNED HAM**

Shall be of the best quality boneless ham, full weight, in key-opening tins of 2 pounds each, weight of tins not included. Each tin to be marked with contents, name of contractor, name of packer, brand, and date of packing, and to be properly lacquered. Each dozen tins to be enclosed in a substantial box made of well-seasoned pine or spruce, properly nailed; sides to be  $\frac{3}{4}$ " and ends 1" thick. Boxes to be marked on one end with contents, name of contractor, date of packing, and the stamp provided for inspected meats by the Secretary of Agriculture, and to be free from all other marks.

The contractor shall guarantee that the ham will keep good in any climate for 1 year from date of delivery.

#### **TINNED BACON**

To be dry salt-cured, cut from 10-pound average bellies when laid down; square cut, seedless; from light prime hogs in good condition; sweet and sound; a good streak of lean in each piece; not too fat; less than  $2\frac{1}{2}$ " thick at shoulder end; well cured.

To be put up in flat, rectangular, key-opening cans (vacuum process) of 5 pounds net weight each; tins to be marked with contents, name of contractor, and date of packing, and to be properly lacquered; 2, or at most 3, pieces of bacon of about equal weights (no scraps) to be put up in each can; the contents of each can to be wrapped in vegetable parchment paper.

Tins to be enclosed in a substantial box, made of well-seasoned pine or spruce, properly nailed; the sides, tops, and bottoms to be made  $\frac{3}{4}$ " thick, and the ends to be 1" thick, when finished; each box to contain 8 tins, and to be distinctly marked, on only one end, with contents (stating net weight), name of contractor, and date of packing. Each case must bear thereon the stamp provided for inspected meats by the Secretary of Agriculture. Cases must be free from advertising matter.

The contractor shall guarantee that the bacon will keep good in any climate for 1 year from date of delivery.

#### **LARD**

To be made from absolutely fresh-killed properly chilled hogs. To contain only body and leaf fat (no head, foot, or gut fat to be used). To be white in color, without bleaching, agitation, use of chemicals,



or any other means of artificial coloring. To be thoroughly cooked by steam heat.

Lard to be chilled to a state of being liquid and then run into square tins of 5 pounds each, net. Tins to be hermetically sealed, with all seams soldered, and to be properly lacquered. Tins must be thoroughly cleaned before being packed into wooden cases. Each tin to be marked with contents, name of contractor, and date of packing.

The contractor must furnish free of charge, with each delivery, a certificate from a licensed produce-exchange inspector that the deliveries are what are required by the specifications in regard to quality of lard and packing.

The contractor shall guarantee that the lard will keep good in any climate for 1 year from the date of delivery.

To be packed in boxes made of planed white pine or spruce; tops, bottoms, and sides to be  $\frac{7}{8}$ " thick; ends to be 1" thick, when finished. All cases to be strapped with  $\frac{1}{2}$ " flat iron, and distinctly marked, on one end only, with contents (giving net weight), name of contractor, and date of packing. Each case to contain 8 tins. Cases to be free from advertising matter.

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### BUTTERINE

**81.** Butterine, or oleomargarine, is composed of oleo oil, neutral lard, cottonseed oil, and genuine butter, with a small proportion of moisture and salt, and with or without coloring matter.

The manufacture of this product is carried on in packing houses where state statutes permit its manufacture. This article has to a large extent replaced natural butter. Contrary to the general impression, butterine is made of the highest-grade material and, aside from the natural butyric and other flavors, is almost identical in composition with genuine butter. The highest grades of butterine have as much as 33 per cent. of genuine butter in their composition and others 25 per cent. This proportion may be and is varied at will by the different manufacturers. Each manufacturer has his individual formula, but as every factory in the United States is under direct government supervision, it is obvious that only materials of unquestioned healthfulness may be used (see *Packing-House Industries*, Part 1).

Each factory is required to make a daily report of the exact quantity and kind of materials used and also the num-

ber of pounds of butterine produced from these materials. This report must be made under oath to government officials, and severe penalties are incurred for infractions of the regulations.

The manufacture is attended with the most scrupulous cleanliness, not only as a matter of personal convenience, but as an essential in producing a merchantable article of trade, as without this cleanliness good butterine cannot be made.

A federal statute vitally affecting the manufacture of oleomargarine went into effect on July 1, 1902. This law imposes a tax of 10 cents per pound on oleomargarine, or butterine, used for domestic consumption, in which yellow coloring matter is introduced. The effect of this legislation has been to reduce considerably the number of establishments formerly engaged in the manufacture of this article. For uncolored oleomargarine, that is, butterine manufactured from the materials in their natural state and without being colored in imitation of butter, a federal tax of only  $\frac{1}{4}$  cent per pound is imposed.

**82. Ingredients Used in Butterine.**—As previously stated, the quality of the ingredients used in making butterine is of the highest. Their condition and preliminary treatment are as follows:

The *milk* used is received in cans surrounded by felt casings, to protect it from changes of temperature. This milk is poured into a receiving vat, from which it is pumped through a fine strainer, to remove all impurities, into a centrifugal separator. In this machine, the cream is separated from the milk at a temperature of 80° F., the milk being of no further service to the butterine maker. The cream flows through block-tin troughs to a Pasteurizer, where it remains until Pasteurized. The temperature used here is 170° F.

The *cream* is then allowed to ripen, that is, acquire acidity, for 24 hours at a temperature of 60° to 70° F., when it is ready for mixing with the other ingredients for churning.

The *neutral lard* used for butterine does not need to be grained, as it is used in a molten condition. The same applies with equal force to the *oleo oil*.

The *cottonseed oil* used is of the grade known as *butter oil*—the choicest grade of this material.

**83. Churning and Finishing the Butterine.**—The churns used for producing butterine are fixed, upright, sheet-iron cylinders capable of holding a charge of about 600 pounds of mixed material. The churns are partly enclosed on the top with curved sheet iron, and inside the churn are paddles fixed to a revolving shaft. When churning, this shaft with the paddles makes from 500 to 600 revolutions per minute.

The proportions of the different ingredients, as previously mentioned, vary. The following proportions for 100 pounds of butterine are those used by a manufacturer that makes about 15 tons of butterine daily.

Cream sufficient to produce 15 pounds of butter; cottonseed oil, 15 pounds; neutral lard, 35 pounds; and oleo oil, 35 pounds. The proportion of butter color varies with the season and the trade; from  $\frac{1}{2}$  to 1 ounce per 100 pounds of butterine is the usual amount added. This is placed in the churn with the other ingredients at the time of churning when colored oleomargarine is desired. Otherwise, the process is carried out as described without the use of coloring matter. The only coloring matter that can be used in domestic food products at the present time is pure annatto (see *Organic Chemistry*). Aniline colors were formerly used in these goods, but their employment is now prohibited (see *Packing-House Industries*, Part 1).

**84.** The desired weights of the various ingredients are run into the churn, and the mixture is churned by means of the revolving paddles for 6 or 7 minutes, when the operation is completed. The best temperature for churning is about 90° F., and the various ingredients are introduced into the churn at temperatures to obtain this. The oleo oil and neutral lard are run in at about 110° F., the cream at about 70° F., and the cottonseed oil at normal room temperature.

The butterine is now run from the bottom of the churn into tanks, or vats, of ice-cold water, to produce the requisite butter grain. This water is kept cold by having a constant supply of ice in it. Some manufacturers place cakes of ice in the bottom of the vats, over which the water flows constantly, thus maintaining a steady temperature of about 34° F. The churned product is allowed to remain in these vats with the water for about 10 minutes, or until it has acquired a firm *set*, when it is thrown, by means of wooden shovels, on inclined tables and permitted to drain. The temperature of this room is kept at 70° F. At this stage, the butterine is salted with an amount varying with the requirements of the trade. From  $\frac{1}{4}$  to  $\frac{3}{4}$  ounce of salt to each pound of butterine is sprinkled over the mass, which during the 10-hour period of draining is turned over three or four times to allow the water to drain from it.

This is generally practiced at night, so that the material is ready for working the next day, when the butterine is worked with the regulation butter worker, to press out the superfluous water and to distribute the salt evenly. A very small amount of sugar, from  $\frac{3}{4}$  to 1 per cent., is usually mixed with the salt for the purpose of "toning down" the harsh taste of the latter.

85. A peculiar fact in connection with the butterine industry is that the manufacturers almost universally employ Ashton salt, an English product, to salt their butterine. It is claimed that a far better product can be made by the use of this salt than by the use of any domestic salt. Butterine is packed in regulation butter tubs, on every package of which is placed the usual revenue stamp and a penalty label. It is also made into pound prints resembling butter and wrapped similarly in parchment paper. Very little labor is attached to the making of butterine, a few employes being able to produce large quantities daily.

In the United States, the names "butterine" and "oleomargarine" are used synonymously. In Europe, however, oleomargarine is almost always termed "margarine."

**86. Manufacture of Margarine by the Nlesse & Bolt Process.**—An emulsion of the yolk of eggs and cream is first prepared. This is mixed or beaten afterwards with milk, soured milk, or aigret (blue milk), according to requirement. After intimate mixture by churning, so as to obtain a sort of egg milk or egg butter, a mixture of fats and oils, prepared previously, is added, either gradually or at one time. The conversion into artificial butter is then carried on in the usual manner. The ulterior treatment of the product does not differ from that pursued in the margarine industry.

The new and essential feature of this process consists in the incorporating and mixing at first, and without the addition of any sweetening matter, of the yolk of eggs with any butyrous fat, so as to prepare a kind of egg milk or butter; then, in mixing this product with the margarine fats in such a manner as to secure an intimate incorporation or perfect distribution of the egg yolk in the final product.

In consequence of this intimate incorporation or distribution, the milk and the egg yolk are much better connected with the constituents of the margarine, so that, with this process, the cooling or washing water, with which the final product is to be treated, flows off in a state that is only slightly clouded. The beating of the milk or cream with the egg yolk and egg fat, the substance of the egg as well as of the milk, and the introduction of the fatty matters connect the components that cannot be butyrified, and at the same time allow the absorption or utilization of all the valuable constituents of the lactic liquid.

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## GLUE

**87.** Glues are now made in many packing houses from raw material that was at one time sold to glue manufacturers and from liquors that were formerly wasted. While perhaps not properly belonging to the packing industry, nevertheless a short account of the method of making glue will be given.

The chief sources of glue in the packing house are the

waters or liquors from the boiling of cattle and sheep heads, feet, and bones, and those from sinews, hide trimmings, horn piths, calves' heads; and pigs' feet. In making glue, a thorough knowledge of the raw material is necessary in order to produce good results. In this manufacture, as in all others, poor material will never yield a high-grade, finished product. Material in prime condition, if allowed to lie around in heaps or be subjected to incipient decomposition, will very quickly become unfit for use as glue; or if used, will produce only low-grade, weak, and foul-smelling glues. To obtain good glues, it is necessary to have the stock in a sound, sweet condition.

**88. Glue Stock.**—The glue stock may be either "green" or "dry," "green-salted" or "dry-salted." Green stock consists of material in the fresh state, such as fresh hide pieces, sinews, calves' heads, feet, etc. Dry stock consists of glue-making material, such as bones, etc., dried, without salting or other treatment. Green-salted material comprises fresh stock that has been cured by means of salt, such as pieces of salted hides, sinews, calves' trimmings, etc. Dry-salted goods consists of trimmings, etc. from South American hides, rawhides, etc.

**89.** In examining glue stock for utility, the examination should include, for *dry* and *dry-salted stock*, the gain in weight by soaking over night in water. This should be about 50 per cent. of their original weight, and, in addition, the soaked pieces should be tough and of firm texture. The odor of both the soaked stock and the water should not be strong. If such is the case, the stock is moldy or the gelatinous matter has been destroyed by insects. The impurities, consisting of dirt and salt, should not exceed 5 or 6 per cent.

*Green-salted stock* should be examined for the purpose of determining whether it contains any decomposed, discolored, slimy, or heated pieces. The latter, if not in a state of decomposition, are bordering on it. The total amount of salt and moisture for this material should not exceed 40 per cent.

The *bones* in the packing house designed for glue should not be overcooked; that is, they should be smooth and hard and not have a chalky, white surface. The latter condition indicates that most of the glue has already been cooked out of them. Soft bones, such as rib bones, yield more glue than the hard bones of the legs and thighs. Bones that have been exposed to weather influences were formerly supposed to yield only little glue of poor quality, but by a recently devised secret process, these bones may be made to yield an excellent light-colored glue.

*Horn piths* should be free from the skin covering and should not be discolored from drying on steam coils. If the tips of the piths are easily broken off, it shows that they have been subjected to a very high temperature, and much of the gelatinous matter thereby destroyed.

*Fresh glue stock* presents no difficulties in the manufacture of glue; but care must be taken to keep it from becoming decomposed before using.

**90. Bone Glue Liquor.**—One of the chief products of the packing-house glue department is **bone glue**, of which there are many qualities, varying from a fine white gelatine to dark-colored, low-grade glues. One method of preparing this product consists in cooking the bones in open vats and evaporating the resultant glue liquors to the desired density in the vacuum pan, from which the liquors are run into the forms for cooling. As many cookings of bones for glue liquor are made as is practicable; that is, the bones are used as long as the liquors obtained contain sufficient glue to make evaporation profitable for forming the glue jelly.

Another method of producing glue liquors is by cooking the bones under pressure. The same principle is applied as in other cases; such, for example, as cooking the bones in tanks under a pressure of 10 or 15 pounds per square inch for two periods of 2 hours each. The yield of glue by this method is better than that obtained from cooking the bones in open vats. By the pressure method, from 11 to 14 per cent. of glue is obtained, while the open cooking yields only

from 6 to 10 per cent. When cooking the bones in the tanks under pressure, water sufficient to cover them must be added.

Bones are sometimes leached with acid, to dissolve the inorganic matter from them. For this purpose, the bones should be as free as possible from grease, and also tough and hard. The bones are covered with dilute hydrochloric acid. They remain covered for some time, depending on the size of the bones, generally from 3 to 4 weeks. The bones after this leaching are soft and spongy and have a rather strong odor. The material is then known as *raw gelatine*, and is suitable for the best grades of bone glue and gelatines.

The glue liquors while hot are run to the settling tanks, where they are allowed to settle and clarify. Any grease appearing on the surface is carefully removed, as it is important to have all glues as free from grease as possible.

**91. Horn-Pith Glues and Gelatines.**—In using horn piths for making glues and gelatines, they are leached with hydrochloric acid of 2° Baumé or with phosphoric acid of 6° Baumé in vats having perforated false bottoms. When the horn pith can be cut through easily in any direction with a knife, the leaching is finished. The horn piths are then drained free from acid, which is replaced with clean, soft water until all traces of acid are removed. This material furnishes fine gelatines and glues on cooking. From 30 to 35 per cent. of raw gelatine may be obtained from dry horn piths; and from the dry, raw gelatine, about 90 per cent. of glue. When phosphoric acid is used for leaching, from 6 to 8 weeks is required for leaching the horn piths.

**92. Head Glue Liquor.**—The glue liquors from cooking heads and feet, previously described, yield on evaporation light, yellowish-colored glues, closely approaching white. The liquor on drawing off from the cooking vats has a density of about 2° Baumé. It is allowed to clarify by settling, and is then evaporated in the vacuum or other apparatus to the desired consistency, when it is run into the jelly molds, cooled, cut, and dried in the usual way.



**93. Clarification of Glues.**—When glue liquors are made of sound stock, they come from the cooking vats in a clear condition, and, on standing a few hours in the settlers, become easily clarified, any impurities rising to the top with the grease or settling at the bottom. The glue liquor after settling is tested for clearness, and, when in a satisfactory condition, is evaporated either in the vacuum pan or other apparatus and run into forms for glue jelly.

The first runs of glue liquors in general are easy to manipulate, but the last runs, containing the residual glue stock, are usually muddy and contaminated with impurities. This class of material is most frequently made into colored glues by mixing zinc oxide with them, thus producing a good-looking, merchantable article.

It is necessary for glues to have an acid reaction in order to clarify by settling. Where a neutral or alkaline condition exists, it is better to clarify by sprinkling a solution of alum into the glue solution. Albumin is used at times as a clarifying agent with good results. The glue liquor is cooled to about 140° F., when the solution of albumin is added and the whole stirred thoroughly and then heated just short of the boiling point. The albumin in coagulating entangles the impurities in the glue liquor and settles to the bottom. The addition of a small amount of ammonium chloride with the albumin makes the clarification more complete.

During recent years, in the clarification of glues, the filter press has been brought into use. If a decolorizing material, such as bone black, is mixed with the glue liquors, on pumping the mixture through the filter press, a clear, brilliant, and somewhat bleached product is obtained. In many establishments, this method has superseded the old way of allowing the glue to clarify itself by settling, on account of the time saved and the reduced liability in warm weather of the warm glue liquors becoming *sour*, or decomposed, and thus rendered useless.

**94. Bleaching Glue Liquors.**—The bleaching of glue liquors is practiced a great deal by modern glue makers.

Bones, before cooking, if covered with a 1-per-cent. solution of sulphurous acid for 24 hours, are bleached to a considerable extent. Such bones are washed free from acid, and when boiled furnish a very light-colored glue.

A very common method of bleaching glue liquors is to pass washed sulphur-dioxide gas through them until the desired light color is obtained. This is the most common and the cheapest method of bleaching. Liquid sulphur dioxide is now manufactured for this purpose, and is transported in heavy iron cylinders similar to those used for anhydrous ammonia. While the sulphur-dioxide method of bleaching is cheap, it cannot always be used with good results on very dark-colored glue liquor.

Other bleaching agents employed are zinc salts, such as sulphate and chloride, but, unless carefully used, their presence in the glue is liable to be very detrimental.

In Germany, limed glue stock is treated with hydrochloric acid and chloride of lime for about  $\frac{1}{2}$  hour, after which it is thoroughly washed. If this treatment is continued too long, however, the stock will become hard and almost insoluble. The so-called Cologne glues, which are very light-colored, are said to be produced by this treatment.

Peroxide of hydrogen has been used for bleaching glues and answers the purpose well. It will turn the darkest-brown glue liquors into a light-yellow color almost instantly. The item of cost, however, has prevented this material from assuming commercial importance.

**95. Preservatives Used in Glues.**—Preservatives are frequently used in glues. Sulphur dioxide, in addition to bleaching glues, acts as a preservative for them. The preservatives most commonly employed are the zinc salts—the oxide, sulphate, or chloride. At the same time, the sulphur dioxide has the additional advantage of producing a light-colored glue. Alum is also employed as a preservative, but it is liable to give a flaky appearance to the glues if used in too large quantities. Formaldehyde has of recent date been employed as a glue preservative. If, however, an

excess over and above that necessary for preservative purposes is added to glue liquor, the glue will be rendered insoluble almost immediately.

**96. Concentration of Glue Liquors.**—Glue liquors may be concentrated by evaporating them in jacketed kettles, in evaporating vats provided with steam pipes, or by means of a revolving steam-heated drum, similar to Fig. 7. With all these methods, the evaporation takes place under ordinary atmospheric conditions. The results in many cases are very satisfactory, but all open evaporators have the disadvantage of subjecting the glue liquors to a high temperature, which is very detrimental to the strength of the finished glue. With many of these evaporators, the heated iron surface reaches a temperature of nearly 300° F., which naturally scorches the glue, forms a crust on the heated surface, and thus hinders rapid evaporation. The glues produced by open evaporators do not compare favorably in strength and color with those made of the same kind of material by evaporation in a vacuum apparatus.

The concentration of liquors in the vacuum apparatus is accomplished by producing a partial vacuum in the apparatus, thus partly removing the atmospheric pressure from the liquid placed therein. By exhausting the air and producing a vacuum of 8.7 pounds per square inch, as shown by the vacuum gauge, the liquor enclosed in the vacuum pan will boil at a temperature of 170.1° F. The lower the temperature at which any glue is made, the better will be its color and strength. This is especially true of high-grade glues.

**97.** Vacuum evaporators are operated either by direct steam or by exhaust steam from an engine. Another advantage in using this kind of apparatus is that less fuel is required for the evaporation of a given weight of water. In the ordinary vacuum pan, 1 pound of coal will evaporate upwards of 8 pounds of water, while with open evaporators, excellent use is made of the coal if 1 pound evaporates 6 pounds of water. With a vacuum pan of three "effects,"

or chambers, an evaporation of 24 pounds of water is obtained from 1 pound of coal. The economical principle of the multiple-effect vacuum pan consists in utilizing the heat over and over again. The steam introduced into the tubes of the first effect evaporates a quantity of water, and the steam thus formed passes into the tubes of the second effect. The steam produced by this evaporation passes into the third



FIG. 12

effect and evaporates still more water. It has been demonstrated, however, that more than four effects cannot be used satisfactorily. Fig. 12 shows a modern multiple-effect vacuum apparatus with three effects.

The single-effect vacuum pan is used where there are comparatively small quantities of liquor to be evaporated. But in the largest packing houses, the multiple-effect vacuum pans are employed in concentrating glue liquors.

**98.** With either kind of apparatus, open or vacuum, the clarified glue liquors are evaporated to a thick consistency, so that they will set to a firm jelly within 10 or 12 hours. The concentrated glue liquors are run from the evaporating apparatus into molds, or boxes, for forming the desired cake of jelly. • These molds are usually made of galvanized iron and hold about 50 pounds of the glue liquor. They are made flaring, so that the glue jelly may be easily emptied from them. Any desired shape may be used, as there is no general standard.

The boxes are filled to within  $\frac{1}{2}$  inch of the top and are allowed to set in a well-ventilated room protected from extremes of temperature until the jelly has become hard and firm. Some establishments set the boxes in a trough of cold, running water and allow them to be cooled in this way. Under no circumstances should the glue liquor be allowed to freeze or to remain too long in a moderately warm temperature. In the former case, the glue jelly will become so brittle that it cannot be cut, and in the latter, the liquor will decompose and become worthless. The jelly in the boxes, when firm and in condition to be handled, is ready for cutting into sheets.

A patented process for cooling, setting, and cutting the glue by a continuous operation is in use in one large factory, not a packing house. The glue liquor is chilled on a brine-cooled cylinder, which, revolving slowly, dips the lower part into the glue liquor and carries sufficient of this liquor on its surface to form, within one revolution, a thin layer of firm jelly. This can be wound off the cylinder as an endless ribbon, cut by the machine into suitable sizes, spread on frames, and sent to the drying room.

**99. Cutting Glues.**—The glue jelly is usually cut into sheets by wire machines, although other kinds of cutting apparatus are used. The wire machines consist of frames of steel with wires so set as to produce a slice of glue jelly of the desired thickness. In the old-style machine, the jelly is cut by movable wires; in the new style, the wires are sta-

tionary, being set in steel frames. These frames are about 2 feet apart from one another, in line, so that when the cake of jelly moves on an endless belt, each wire in turn cuts a slice of jelly. For cutting low-grade glues, a knife-cutting machine is used. The circular knives are set on a shaft and are spaced sufficiently far apart to make the desired thickness of the sheet of jelly. With this machine, the tops with the bubbles and the bottoms with the settlings are removed; later these are remelted with fresh material.

The sheets of glue after cutting are spread on nets of galvanized-iron wire having meshes of about 1 inch. These nets have a framework of wood that sets into another frame built on a truck. As fast as the nets are covered with sheets of glue, they are placed on the truck. This truck when filled is run into the drying room, where the glue remains until dry. Although perfectly dry to the touch, the glue ordinarily contains from 10 to 13 per cent. of moisture. Excessive drying of the glue is not desired by the manufacturers for obvious reasons. In a heated chamber furnished with fans or blowers, the drying operation occupies at the present day only a few hours; whereas, formerly, by exposure in airy lofts, it took several days.

Sheets of glue that are imperfect or broken, if of cheap quality, may be made into ground glues by passing the material through a grinding mill. Where the glue is of high quality, imperfect sheets and pieces are remelted with the next batch of high-grade material. The lighter the glue, other things, such as strength, clearness, etc., being equal, the better the price obtained for it.

**100. Yields of Glue.**—From green-salted hide trimmings, sinews, etc., from 18 to 20 per cent. of glue may be obtained. These materials, when dry yield from 50 to 65 per cent., according to quality and condition. From hard, dry bones, an average yield of 18 per cent. is obtained. From green rib bones—practically the only way this material is worked up for glue—an average yield of 12 per cent. of glue is obtained.



# PACKING-HOUSE INDUSTRIES

(PART 3)

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## VARIOUS ANIMAL PRODUCTS AND THEIR DISPOSITION—(Continued)

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### CURED MEATS

1. The curing of the meat products of the packing house is such a wide subject that it cannot be treated in full here. The principle underlying the curing process, in either the wet (pickle) or the dry (salt) way, is the prevention of putrefaction of the products by means of salt and other curative agents. Among the latter are saltpeter, wood smoke, vinegar, etc. Salt alone may be used, but to obtain the best results for mild cures, its harsh effect is toned down with sugar, sirup, or molasses. When these saccharine substances are used in conjunction with brine or dry-salt curing, the meats are termed *sweet-pickled meats*.

In connection with the curing and preserving of meats, the wholesomeness of any colors, preservatives, or other substances added to foods of any description in the packing houses, is determined by the Secretary of Agriculture, who promulgates the names of those substances which are permitted or inhibited in food products. The secretary also determines from time to time the principles that shall guide the use of colors, preservatives, etc., and the principles so established become a part of the existing regulations. Where meats are to be exported, however, the use of pre-



servatives is permitted under certain conditions (see *Packing-House Industries*, Part 1).

**2. Dry-Salt Meats.**—Meats that have been cured by covering with salt and piled about 6 feet high on the floor of the curing cellar are known as **dry-salt meats**. A small proportion of saltpeter is frequently mixed with the salt, to give to the lean meat the ruddy appearance always desired. These cuts of meat are taken down and repiled three or four times during the period of curing. This operation is technically termed *overhauling*, the object being to allow the salt and brine, made by the moisture in the meats, to affect all parts of the cut equally. The time allowed for curing these articles in packing houses is based on 1 day per pound of the weight of the cut. The dry-salt method of curing is most largely and almost exclusively applied to pork products. Dry-salt meats are shipped for domestic trade in bulk; and for export trade, packed with borax in boxes.

**3. Wet-Cured Meats.**—Both pork and beef products are cured in *brine* or in *pickle*. The distinction between these terms is that the former is a solution of salt in water, while the latter is brine, to which various permitted ingredients have been added, such as sugar and saltpeter.

Each establishment has its own formula for making pickle and its own method of curing in this solution. The time required for curing meats in pickle varies according to many circumstances, such as the strength of the pickle (percentage of salt) and the size and nature of the cut. While a piece of bacon weighing 4 or 5 pounds may be cured in 21 days, a very large-sized ham may require over 100 days, all the pieces of meat being subject to frequent overhauling.

Small pieces of beef to be used for canning purposes are cured in 15 days, as their small size—4 to 6 pounds—permits them to be readily permeated by the pickle. Even then, as with all pickled meats, they require frequent disturbance or transfer from one vat to another to insure a uniformly cured product.

**4. Smoked Meats.**—After coming from the pickling process, hams, bacon, and some other cuts are subjected to **smoking** as a further means of assisting in the preservation of the products. The object of putting the meats into smoke is twofold—first, to evaporate a portion of the moisture of the meat and, second, to impregnate the products with creosote and other empyreumatic compounds, the latter giving to smoked meats their characteristic flavor.

The meats are hung in a smoke house; that is, an enclosed compartment, at the bottom of which slow, smoldering fires are kept burning. Hardwoods and sawdust are used for fuel to produce the required smoke, as soft woods contain too much resinous matter, which produces ruinous effects on the meat.

The products remain in contact with the smoke for a period depending on many conditions, which are judged by personal observation. Among these are the depth of color desired, size of pieces, temperature, etc. A shrinkage of weight always takes place in this process, which depends also on many circumstances; a general average of loss in weight may be taken as from 12 to 14 per cent.

The smoked products are removed from the smoke house and allowed to cool at the natural temperature of the room, when they are ready to be sold or to be packed for shipment.

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### BLOOD ALBUMIN

**5. Preparation.**—Blood albumin is one of the products made from the blood of slaughtered animals. The blood as it comes from the animal is caught in shallow pans, each being just large enough to hold the amount from one animal. The blood is then allowed to rest without stirring or agitation until it clots. It is an essential part of the process of manufacture that the blood should not be stirred, or it will be defibrinated and the proper separation cannot be made.

After clotting, the clot is scored into small squares with a sharp knife, and these pieces are placed in shallow pans

with perforated bottoms through which the serum or albumin drains from the clot. The dark-red clot is used for the manufacture of the ordinary dried blood. When separated from further impurities and dried under suitable conditions, the serum that drains through is the product that forms the dried albumin of commerce. The serum at this stage of the process is of a pinkish or light-red color, which is due to the presence of some red corpuscles that have been imperfectly separated by clotting.

6. The next operation is to separate these red corpuscles, as the quality of the finished product depends on the perfection of this separation. The serum is placed in shallow pans, which are about 3 feet long by 18 inches wide and 4 or 5 inches deep. At the center of the bottom of these pans is a perforated rubber stopper, through which a  $\frac{1}{4}$ -inch glass or lead tube extends until it reaches just above the surface of the liquid. The pans are filled with the serum and allowed to stand in a cool place for a few hours, during which time the red corpuscles begin to sink. As the liquor clears at the top and the corpuscles sink lower and lower, the tube is gradually lowered to draw off the clear serum into suitable vessels placed underneath, this operation being performed at intervals as long as the liquid runs off clear. When it is seen that further continued settling will no longer produce a clear liquid, the receptacle is changed and the liquid that afterwards comes over is used in making inferior grades of the product.

The serum that has drained off clear is of a very delicate pink color. It is placed in small, shallow, smooth enameled plates, resembling ordinary pie plates, each of which holds about  $\frac{1}{2}$  pint. Previous to filling, the plates are slightly greased. The plates with the serum are then placed in a drying room and kept at a temperature of about 110° F. until the product dries. The dried albumin is then scraped off the plates, which operation is easily accomplished, as the film of grease prevents it from adhering to the plates. It is important that the temperature of the drying room

be kept as low as possible and yet dry the product in a few hours. Otherwise, there is danger of the serum coagulating and thus ruining the product.

The darker-colored albumin is dried in the same manner as the foregoing. The first and best grade is a very clear and pale amber-colored product, its quality and value depending very much on its lightness in color. Blood albumin finds extensive use in the textile industries in printing cotton fabrics.

7. As liquid blood is a very perishable product, it is necessary that all the operations up to the drying should be performed at a low temperature, to avoid decomposition and consequent inability to make albumin from the blood. It was customary in former times to manufacture the product only in winter. With the modern system of artificial refrigeration, however, it is now possible to turn out a uniform product at all times, independent of the seasons.

In the very latest and most approved methods of manufacture, the separation of the serum is accomplished by centrifugal machines, and the evaporation is subsequently conducted at a low temperature in a vacuum apparatus. Most of the product on the market, however, is still made by the old process, but it will undoubtedly soon be superseded by the new methods.

The yield of blood albumin from blood is theoretically 50 per cent.; but this is never realized in practice. Five bullocks yield about  $4\frac{1}{2}$  gallons of serum, which when dried gives  $4\frac{1}{2}$  pounds of albumin. The blood of twenty sheep or thirty-four calves gives the same quantity of blood albumin.

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### DIGESTIVE FERMENTS

8. All known digestive ferments belong to the class of soluble, or unorganized, ferments. They are sharply distinguished from the insoluble, or organized, ferments, such as yeast, in not having the powers of self-nutrition and self-multiplication. In composition, digestive ferments resemble

proteid substances (see *Organic Chemistry*), and contain carbon, hydrogen, oxygen, and nitrogen in somewhat similar proportions to albumin. None of these ferments has yet been obtained in a state of absolute purity. All digestive ferments are soluble in water and are all diffusible, though with difficulty, through animal membranes and parchment paper. They are precipitated from their watery solutions by absolute alcohol, but, unlike other proteids, with the exception of peptone, they are not truly coagulated by alcohol. When the alcohol is removed, the ferments are still found to be soluble in water and to retain their activity unimpaired. All digestive ferments are coagulated and rendered permanently inert by the heat of boiling water; and when in solution, they are coagulated and destroyed by a temperature of about 160° F.

The digestive ferments produced in the packing house are mainly pepsin and its products, the former, however, being most commonly made. Beef peptone is made by only two large packing houses in the United States.

**9. Pepsin.**—The mucous membrane of the stomachs of hogs is the chief source of pepsin, although the stomachs of other animals may be used. The large and steady supply of material from hogs makes it most conveniently available. The stomachs are emptied of their contents and thoroughly washed in cold water. Any food that clings to the mucous membrane is removed by hand. In the washing, violent, energetic motions should be avoided, or a great deal of the pepsin-containing membrane is liable to be removed mechanically. Gentle handling is essential during the first stages of the preparation. The outsides of the stomachs are trimmed away.

That portion of the stomach reserved for the pepsin is chopped into small pieces and placed in water acidulated with from 3 to 4 per cent. of pure hydrochloric acid. The receptacle used for this purpose in the packing house is usually a large open-head hogshead. The material is allowed to remain in this weak acid solution and is kept at a temper-

ature of 104° to 122° F. until it undergoes self-digestion. This operation is materially assisted by frequent stirring, but from 36 to 48 hours, and sometimes longer, is required for the solution to be effected. At this stage of preparation, the liquid is very prone to decomposition, especially in the presence of ozone occasioned by thunder storms, and great watchfulness is required. An innocuous, antiseptic condition is occasioned by passing sulphur dioxide into the solution from a generator until the solution smells strongly of the gas. This operation serves at the same time to bleach the product.

In this condition, the liquid is allowed to stand and clarify itself by the precipitation of the mucus, without causing any material injury to the pepsin from putrefactive changes. The resulting clear liquid is decanted or drawn off, and to it is then added common salt, the temperature of the liquid being maintained at 94° F. until complete separation of the pepsin results by precipitation. The pepsin thus obtained—the floating scum—when collected, pressed, and dried constitutes *crude pepsin*, which even in this form is marketable, being very active and meeting certain requirements of trade. The product has a faint but not disagreeable odor, a brownish-yellow color, and a slightly saline taste.

**10. Purified Pepsin.**—The crude pepsin, preferably but not necessarily in the moist state, is dissolved again in weak hydrochloric acid, and the solution thus obtained is subjected to dialysis by any suitable means until the salt has been eliminated from the pepsin solution. The purified liquor is then concentrated, preferably in vacuum apparatus, care being exercised not to have the heat exceed 100° or 105° F. The concentrated solution is then dried on glass plates, the edges of which are raised to hold it. These plates are about 15 inches wide and 20 inches long, with the projecting edge  $\frac{1}{4}$  inch high. The thin layer on the plates is dried as rapidly as possible in a drying room that is arranged with shelves to hold a number of plates. The temperature should not exceed 102° F. in this room, which

must be well protected from dust. When thoroughly dry, the pepsin (now the so-called pure pepsin of trade, known as *scale pepsin*) is scraped from the glass plates. It will have a digestive power of about 1 to 3,000—that is, 1 part of pepsin will digest 3,000 parts of freshly coagulated egg albumin—if the operation has been properly performed. By further redissolving and dialyzing, the digestive power may be greatly increased, but ordinarily the price obtained is not commensurate with the labor and expense involved. The preceding strength—1 to 3,000—is the standard requirement for pharmaceutical and medical purposes.

**11. Powdered Pepsin.**—The scale pepsin made by the foregoing process is ground in any suitable mill in which the material is protected from the atmosphere during the process of grinding. This is necessary, as the scale of pepsin is so hygroscopic in its nature that attempts to powder it without this precaution will prove futile. Several suitable mills for this purpose, readily available and very serviceable, are on the market. Powdered pepsin is made into pills, tablets, etc., and has the same digestive power as the scale pepsin from which it is made.

The compound preparations of pepsin enter into the field of the pharmacist rather than that of the chemist, and will therefore not be treated here.

**12. Yield of Pepsin.**—The yield of pepsin varies with the class of hog stomachs used. From a test of 3,318 pounds of membranes, trimmed for pepsin making, a yield of 117 pounds of high-grade pepsin was obtained. The weight of membranes from 250 whole hog stomachs was 200 pounds, thus giving a yield of 2.8 pounds of pepsin for each 100 stomachs. Another test from 9,000 stomachs gave a yield of 162 pounds, or 1.8 pounds of pepsin for each 100 stomachs.

The labor attached to the manufacture of pepsin is very slight. Ordinarily, one pepsin maker, with a boy, accomplishes the entire manufacture at a comparatively small cost.

Pepsin in a dry form, in common with all digestive ferments,

permanently retains its properties. What is true of pepsin is true of all digestive ferments in characteristics of this nature. Moisture and heat are favorable to their decomposition and, as an essential quality, they should be so prepared as to have peptone and all other substances of hygroscopic properties eliminated as completely as possible. The digestive ferments remain inert, but are not injured in the least by a low temperature. Pepsin exerts its activity in acid solutions only, while pancreatin acts best in neutral or alkaline solutions.

**13. Valuation of Pepsin.**—The chemist is frequently called on to determine whether a pepsin meets the requirements of the standard strength. The most approved method for the testing of pepsin is that officially given in the Eighth Decennial Revision of the Pharmacopœia of the United States of America. This method is carried out as follows:

Mix 9 cubic centimeters of diluted hydrochloric acid (*HCl* containing 31.9 per cent., by weight, of absolute *HCl* 100 grams, and distilled water 219 grams) with 291 cubic centimeters of distilled water, and dissolve .1 gram of pepsin in 150 cubic centimeters of the acid liquid. Immerse a hen's egg, which should be fresh, for 15 minutes in boiling water; remove the pellicle and all of the yolk; rub the white, coagulated albumin through a clean No. 40 sieve. Reject the first portion that passes through the sieve, and place 10 grams of the succeeding portion in a wide-mouthed bottle having a capacity of 100 cubic centimeters. Add 20 cubic centimeters of the acid liquid, and with the aid of a glass rod tipped with cork or black-rubber tubing, completely disintegrate the albumin; then rinse the rod with 15 cubic centimeters more of the acid liquid and add 5 cubic centimeters of the solution of pepsin. Cork the bottle securely, invert it three times, and place it in a water bath that has previously been regulated to maintain a temperature of 52° C. (125.6° F.). Keep it at this temperature for 2½ hours, agitating every 10 minutes by inverting the bottle once. Then remove it from the water bath, add 50 cubic centimeters of cold distilled water, trans-



fer the mixture to a narrow, graduated cylinder, and allow it to stand for  $\frac{1}{2}$  hour. The deposit of undissolved albumin should not measure more than 1 cubic centimeter.

The relative proteolytic power of pepsin, stronger or weaker than that just described, may be determined by ascertaining through repeated trials the quantity of the preceding pepsin solution required to digest, under the prescribed conditions, 10 grams of boiled and disintegrated egg albumin. Divide 15,000 by this quantity, expressed in cubic centimeters, to ascertain how many parts of egg albumin one part of the pepsin will digest.

The official United States Pharmacopœia pepsin when assayed by the process just given, must be capable of digesting not less than 3,000 times its own weight of freshly coagulated and disintegrated egg albumin.

**14. Apparatus for Making Pepsin.**—The necessary apparatus for manufacturing pepsin and compound preparations of it includes the following:

Mill, sifter, or bolter, percolators, funnels, glass plates for drying, glazed stone jars, the necessary hogsheads, barrels, etc.; all of which may be purchased for an amount not exceeding probably \$600.

For making the pepsin tablets, pepsin glycerol, essence, wine, and aromatic pepsin, a hot-water bath, hot-water funnel, and several glass bottles and funnels are necessary, in addition to the tablet machine. This additional apparatus, sufficient for a large daily output, may be obtained for about \$700 additional, making the total for a complete pepsin manufactory about \$1,300.

**15. Peptone.**—By allowing the solution from which the pepsin precipitate has been removed to cool gradually, the salt will crystallize out. This solution contains practically all the **peptones** (see *Organic Chemistry*), and after the salt has crystallized from it the peptones are left in solution, from which they may be obtained by evaporation and drying, as usual. There is a very limited market for this product, however, and it is not manufactured very extensively. The

physiological characteristics are made use of to a much greater extent in other compounds, such as the beef peptone.

**16. Beef Peptone.**—The compound known as **beef peptone** is made by digesting beef by means of the pancreas of the beef. The tougher and leaner the beef, the better will be the yield of beef peptone. The meat is very finely minced, and to 25 parts are added 8 parts of the pancreas and 4 parts of water. The whole is allowed to digest in a jacketed kettle, at a temperature not exceeding 130° F., for 6 hours, after which time all the solids will have passed into solution through a true digestive process. During this time the mixture must be frequently stirred to facilitate the action. The solution is filtered through cotton-flannel bags in the same manner as beef extract, and the filtrate is bleached the same as pepsin solution, for which purpose the same apparatus will serve.

The bleached solution is evaporated to dryness on a water bath or at a temperature not exceeding 212° F. It may also be economically evaporated to a thick consistency in a vacuum apparatus and afterwards dried. The yield of beef peptone from this process, using tough and lean meat, is 13 to 14 per cent. of the total weight of the meat and pancreas. This yield is rather high for the ordinary run of beef, from which a yield of about 10 per cent. should be obtained.

**17. Pancreatin.**—The product known as **pancreatin** is a digestive ferment existing in the fluids of the pancreas, or sweetbreads, of animals. Pancreatin is ordinarily made from the pancreas of the hog, in a similar or analogous manner to that of pepsin from hog stomachs. This product is not made to any extent in the average packing house, as it borders on the field of the pharmacist.

The pancreatin solution, like the pepsin, is also very susceptible to decomposition, which may be, and usually is, prevented by the addition to the solution of an infinitesimal amount of thymol or chloroform, either of which does not interfere with the action of the ferment.

**18. Rennet.**—The fourth, or true, digestive stomach of the calf is utilized in preparing rennet. This product is not prepared in the packing house, the stomach being simply dried and sold in that condition.

A crude rennet may be prepared by simply trimming the calf stomach free from fat, etc., drying it at a low temperature, and then grinding it to a fine condition. The ground material is packed tightly in a glass or tin percolator, and any remaining fat (which would become rancid through oxidation) is extracted by means of low boiling petroleum, ether, etc. The fat-free, crude rennet is afterwards spread thinly and then gently heated to drive off the odor of the solvent.

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### ANIMAL EXTRACTS

**19. Animal extracts** are made from the various organs of slaughtered animals, and are said to have great virtue in the treatment of diseases of man, in similar organs to those from which the various extracts are obtained. These extracts were first prepared by Doctor Hammond, of the United States. The preparations are obtained from the healthy organs of the animals selected for this purpose. Each organ used is subjected to careful examination, in order to insure freedom from affections in any form.

Among these extracts are *medulline*, from the spinal cord of the bullock; *cardine*, from the heart of the bullock; *testine*, from the testes of the bull and the ram; *ovarine*, from the ovaries of the hog; *musculine*, from the muscular tissues of the bullock; *thyroidine*, from the thyroid glands of the sheep and the bullock; and *cerebrin*, from the brain of the bullock.

**20. Process of Preparation of Animal Extracts.** The original process as described by Doctor Hammond is as follows:

The process of preparation of the extract of these several organs (the heart, etc.), while individually somewhat different, does not materially vary from that used for the brain, which is as follows:

The whole brain of the ox, after being thoroughly washed in water acidulated with boric acid, is cut into small pieces in a mincing

machine. To 1,000 grams of this substance placed in a wide-mouthed, glass-stoppered bottle, I add 3,000 cubic centimeters of a mixture consisting of 1,000 cubic centimeters each of saturated solution of boric acid in distilled water, pure glycerine, and absolute alcohol. This is allowed to stand in a cool place for at least 6 months, being well shaken or stirred two or three times a day. At the end of this time it is thrown upon a porous stone filter through which it percolates very slowly, requiring about 2 weeks for entirely passing through. The residue remaining upon the filter is then enclosed in several layers of aseptic gauze, and subjected to a pressure of over 1,000 pounds, the exudate being allowed to fall upon the filter and is mixed with a sufficient quantity of the filtrate to cover it. When it has entirely filtered, it is thoroughly mixed with the first filtrate, and the process is complete.

During the whole of this manipulation, the most rigid antiseptic precautions are taken. The vessels and instruments required are kept in boiling water for several minutes and are then washed with a saturated solution of boric acid. Bacteria do not form in this mixture under any circumstances, but it is necessary to examine it from time to time, microscopically, in order to see that no foreign bodies have accidentally entered. Occasionally, owing to causes that I have not determined, though I think it is due to variations in temperature, the liquid becomes slightly opalescent from the formation of a flocculent precipitate. It sometimes takes place in a portion of the extract kept under apparently identical conditions with other portions that remain perfectly clear. It can be entirely removed by filtration through Swedish filtering paper, previously sterilized, without the filtrate losing anything of its physiological or therapeutical power.

The foregoing process is the best that has so far been devised for obtaining these extracts, and when used the conditions set forth should be fully and most carefully maintained.

**21.** Innumerable extracts have been made from the different parts of slaughtered animals but many of them have been produced only experimentally, and as yet find no practical application. From the red-bone marrow of calves' ribs is made a *medullary glyceride*, which is used to stimulate the formative processes and to increase the rate of production of red blood corpuscles.

*Andrenalin*, a liquid extract of the little capsules situated above the kidneys, is a valuable local anesthetic and a specific for Addison's disease.

Thyroidine, previously mentioned, is used with great success in the treatment of goiter, and a preparation made from the pancreas of animals has very recently been used for the treatment of cancer.

The field of usefulness of animal extracts appears to be practically limitless, as applied to the human body, and investigations are constantly being made to further enlarge this field. Although the packing house is the source of material used for the preparation of these animal extracts, they are not usually made there.

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## FERTILIZERS

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### FERTILIZER MATERIALS

**22.** Under fertilizer material is included practically all material that cannot be made use of in any other way. At one time the waste material of the packing house was not only a nuisance, but the disposal of it was a source of expense. Now, however, all refuse is utilized by making it into various grades of fertilizers, which are a source of income of no inconsiderable importance. The manufacture of fertilizers from the various waste materials will be taken up at length.

**23. Tankage.**—The name properly applied to the sediment remaining in the tanks where meat scrap, with some bone, is rendered to separate the fat is **tankage**. The name is also applied to the refuse from tanking garbage, the dried product being known as *garbage tankage*. This product, however, is never made in packing houses. The name tankage is also loosely applied to mixtures that consist largely of bone and do not differ greatly in composition from pure bone.

After material has been cooked in the rendering tanks, the fat is withdrawn from it, and when all that can be taken from the tank has been obtained, the cooked, hot, material

is allowed to drop into a box or vat located in front and underneath the tank. Here the material is kept hot by steam pipes in the vat, and whatever grease or fat rises to the surface is skimmed off. The latter is technically known as *skimmings*, and is recooked with the next charge of fresh material.

The water with which the material in the tank has been cooked becomes impregnated with more or less fat and also

FIG. 1

with a very large quantity of nitrogenous material. It is technically known as *tank water* and is the source of *concentrated tankage*, or *stick*. The treatment of tank water will be described later under the heading Concentrated Tankage.

The material in the vat, after skimming, is drained free from the tank water, and while still hot is placed in the tankage or fertilizer press. This operation is ordinarily performed by hand, but in the modern establishments the

tankage is made to flow from above into the press cloth on the forms that are placed on the platform of the press.

**24. Pressing Tankage.**—There are several forms of fertilizer presses in use. Among these are the knuckle-joint, the power-screw, and the hydraulic press. Fig. 1 shows the *power-screw press*, which is the style of fertilizer press preferred by many of the leading packers, and only by the use of this or similar presses have they been able to handle the immense amount of material that is now utilized and made into valuable fertilizer. This press has the advantage of

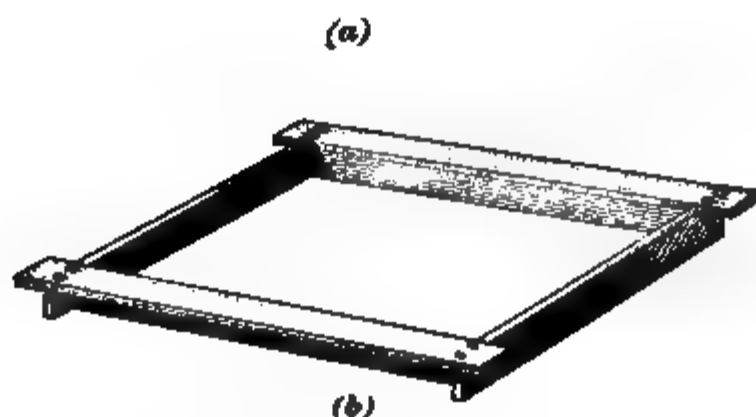


FIG. 2

giving the same pressure at every point, thus pressing a small amount of material as well as a large amount, without the handling of any blocking. It is made very heavy and strong, to stand rough usage, and will give an immense pressure. Although shown with a double platform, it may be fitted with any other style of platform to suit the situation.

**25.** The cloth used for pressing tankage is made especially for this purpose. It is known as *tankage press cloth*, and is made of rather coarsely, but strongly, woven jute. A rack, Fig. 2 (a), is first placed on the platform a of the

press. This rack is square and is made of wooden strips  $\frac{3}{8}$  inch thick by  $\frac{7}{8}$  or  $1\frac{3}{8}$  inches wide. These strips are placed  $\frac{1}{4}$  inch apart, with five or more elm strips 2 inches wide and  $\frac{3}{8}$  inch thick nailed across, as shown. Wrought-iron nails of sufficient length to clinch securely in the elm are used.

The platforms *a* and *b*, which run on a track, may be filled at any convenient place and afterwards run to the press. On the rack is placed a form like that shown in Fig. 2 (*b*). This form is square inside and  $3\frac{1}{2}$  inches deep. It is made by nailing together boards, 1 inch thick by  $3\frac{1}{2}$  inches wide, in the form of the sides of a box. A board is then nailed across each end, as shown, to serve as a guide and to give stiffness. Over this form is spread a cloth, which is filled with tankage until the material is even with the top of the form. The cloths should be sufficiently large to enable the sides and ends to be folded over, thus completely covering the material. The form is then raised and another rack is placed on the layer thus made, the form being placed on this new rack, a cloth again placed over it, and another layer of wet tankage put in as before. From eight to twelve racks are used in one load and as many cloths, less one. When the last layer is made, the form is taken off and a rack is placed on top of the load. The platform is then run on the track *c* to the press, and the pressing is commenced. By placing the racks alternately across and lengthwise of the platform, the built-up load will be less liable to move or to cant over and thus cause the racks to spread. A guide should be used in building the layers, so that the form will always be directly over the last layer. The load consisting of the different layers of material to be pressed is sometimes termed a *cheese*.

The power in pressing is applied by the pulleys *d*, which cause the gears to move the upper part *c* of the press downwards, thereby pressing out the water and grease remaining in the wet tankage. The racks afford channels for this water and grease to run out of each layer. By a reverse motion of the power, the upper part of the press is raised when the pressing is finished.



The advantage of the double platform is that while one load is being pressed on one side *a*, another may be built on the other side *b*.

**26.** In Fig. 3 is shown the *knuckle-joint fertilizer press* with one load pressing and another load of material in layers ready for running under the press when the first

FIG. 3

pressing is finished. The press is shown with double platform and power attachment, although, if desired, presses with single platform and hand-power attachment can be procured. For small packing houses, this press has been found very satisfactory.

**27.** In using *hydraulic presses* for tankage, it is necessary to block the load by placing square pieces of wood between

the load of layers and the upright guides on the press. The

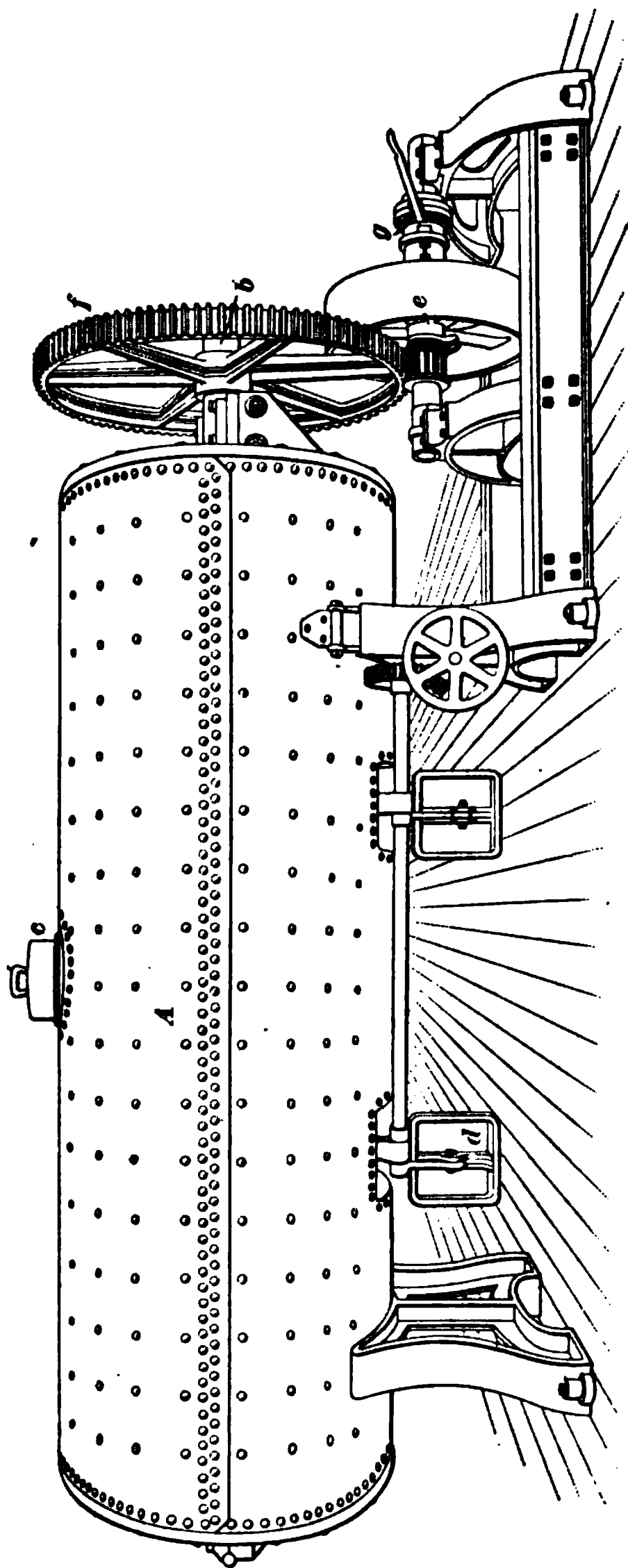


FIG. 4

hydraulic press does excellent and rapid work, and presses the material very much drier than either of the presses illustrated.

The pressed material contains approximately 50 per cent. of moisture after being removed from the press and shaken free from the cloths. The water and grease pressed out of the hot tankage run to a catch basin, where the grease, rising to the top, is skimmed off and recooked with refuse material for No. 2 tallow, or for yellow grease.

**28. Drying the Pressed Tankage.** — The pressed material is now transferred to the drier for the final drying into a

commercial product. Several forms of driers may be had.

Fig. 4 shows one of the most modern makes, which is known as a *single-cylinder drier*. It is extremely simple in operation. The iron cylinder *A* is a jacketed, or double, shell in which are revolving arms, or paddles, operated by the shaft *b*. The fertilizer material to be dried is loaded into the cylinder through the door *c*, which is then closed, and the shaft is started revolving by the large cog wheel *f*, operated by the power applied to the pulley *e*. Steam under pressure circulates through the double shell, and the heat from it drives off the moisture in the material. The odors and gases coming from the fertilizer material pass through the pipes to the condenser, which is attached to all driers. The condenser has jets of water running into it, which, coming in contact with the hot gases, cool them, and at the same time cause the greater part of them to pass into solution with the water. The cylinders of the dryer vary from 3 to 5 feet in diameter, and are from 10 to 16 feet long. The clutch *g* serves to start and stop the power that operates the drier.

The tankage is dried so that it contains 10 per cent. or less of moisture. This operation requires from 3 to 6 hours, depending on the class and quantity of material worked on. It is then allowed to drop out through the doors *d*. The material is so hot that if it were piled up in this condition, it would not become cold and would rapidly decompose. The hot material, therefore, is spread on the floor about 3 inches deep. After the heat has gone from it, the material is shoveled into piles; or if desired for immediate shipment, it is put into second-hand bags, such as salt bags, that will hold about 200 pounds each of the dried tankage.

Where the Wannenwetsch system (see *Packing-House Industries*, Part 1) of rendering is employed, it is not necessary to use any press or dryer for producing the finished tankage.

**29.** Small renderers frequently use a drier in the form of a steam-jacketed drum that is about 6 or 8 feet in diameter and about  $2\frac{1}{2}$  feet in height. This drum is provided on the

inside with revolving or circulating arms for the purpose of preventing the material from sticking to the sides and also to facilitate the removal of the moisture. After the tankage is dried, the door in the side is opened, thus permitting the revolving arms to empty the drier automatically. These driers are built to withstand a steam pressure of 75 pounds per square inch.

**30. Grading of Tankage.**—Tankage is divided into several grades, which are quoted by the percentages of ammonia and phosphoric acid shown by analysis. For example, a 7-30 tankage would be one that analyzes 7 per cent. of ammonia and 30 per cent. of phosphoric acid. Low-grade tankage contains less than 10 per cent. of ammonia and a high percentage of bone phosphate, while high-grade tankage always contains 10 per cent. or more of ammonia, and correspondingly less bone phosphate. Bone tankage, as the name implies, is that containing mostly bone.

Tankage is also classed as *underground*, *crushed*, and *ground tankage*. The former is tankage that is dried without subsequent grinding or crushing of large sinews, meaty pieces, or bones. Crushed tankage consists of underground tankage broken up sufficiently to pass through a screen of about 1- or 1½-inch mesh. Ground tankage is tankage ground to fine condition. This material will pass through a sieve of about ½-inch mesh. The usual difference in trade values of each is \$1 per ton, ground tankage being the most valuable.

Tankage is always valued on the percentage of both ammonia (nitrogen) and phosphoric acid contained in it, the former being always the most valuable component.

**31. Concentrated Tankage.**—In order to make concentrated tankage, also known under the trade name *stick*, the tank water from the cooking of meaty material is evaporated. Tank water contains a considerable amount of dissolved nitrogenous matter, which, when recovered in the

form of concentrated tankage, furnishes a valuable fertilizer material.

The tank water is run to receivers and thence to evaporators, where it is evaporated to a sirupy consistency. The tank water, previous to evaporation, has mixed with it some form of cheap sulphates, such as copperas (sulphate of iron). The proportions used are 500 pounds of copperas to each 2,000 pounds of dry substance in the tank water. The mixture is concentrated to about 30 per cent. of moisture, when it is placed about 1 inch deep in sheet-iron pans that are 30 inches long, 15 inches wide, and 3 inches high. These are placed in a drying oven and the mixture is baked to dryness. The material is then knocked from the pans and ground fine. The product resembles ground blood and will analyze about 15 or 16 per cent. of ammonia on a dry basis. This material, like dry blood, is sold by the "unit" value, being quoted commercially at a certain price per unit. The unit is simply an arbitrary commercial standard, the chemical percentage of ammonia being taken. Each per cent. of ammonia equals one unit per ton.

**32.** When large quantities of concentrated tankage are to be treated, the form of evaporator used is the vacuum pan, which evaporates such quantities in an economical manner. Where small quantities are to be evaporated, the roller evaporator, similar to Fig. 7, *Packing-House Industries*, Part 2, may be used effectively.

It is very essential that some efflorescing material, as copperas, be used in making concentrated tankage, as without this material, the tank water could not possibly be evaporated to dryness. Even if the latter condition could be obtained, the material alone, being very hygroscopic, would absorb moisture so rapidly as to become sticky, lumpy, and consequently, useless as fertilizer material, which must be in convenient form for handling and mixing.

At times, the practice of the smaller renderer is to evaporate the tank water with the copperas to a sirupy consistency,

and then mix this with the pressed tankage before putting the latter through the drier, the whole thus being dried together. In this way, the tank water is utilized and the tankage enriched in ammoniates.

**33. Ground Blood.**—In order to produce ground blood, the liquid blood is conducted from the slaughtered animals into a tank, or vat, where it is boiled with open steam for 20 minutes. This coagulates the albuminous matters and renders them practically insoluble. The clotted blood is then pressed in precisely the same manner as tankage. The pressed-out water has no value and is allowed to waste. The cloth for pressing blood is of closer texture, but of the same material as tankage cloth.

The pressed blood as it comes from the fertilizer press contains about 50 per cent. of moisture. It is broken into small lumps and passed through a disintegrator, which tears it into lumps about the size of a bean. The blood in this condition is then passed to the drier, from which it emerges as dried blood, containing, however, numerous hard lumps that are technically known as *blood screenings*. The blood is screened through a sieve, and the screenings are ground by themselves to the required degree of fineness and mixed with the screened blood. Instead of sifting the dried blood as it comes from the drier, as is done in the large establishments, it may all be put through the mill and ground fine. The hot material is spread on the floor in a thin layer, to allow the heat to escape, after which it is made into a pile or sacked like tankage.

Ground blood is always sold on the unit basis of the ammonia it contains, the percentage of which will vary according to its freedom from extraneous material and moisture. Clean ground blood should contain from 16 to 17 per cent. of ammonia and from 2 to 3 per cent. of moisture. When mixed with refuse, it may not contain over 9 per cent. of ammonia.

Where the amount of blood, in comparison with the tankage, is small, it is usually cooked along with the tank-

age. The resulting fertilizer is sold on a basis of the ingredients it contains.

**34. Raw Bone and Raw-Bone Meal.**—The bones that have not been subjected to pressure in cooking, such as shin, knuckle, jaw, and head bones, furnish raw bone. After these have been freed from as much grease as possible and dried, they are finely ground in a bone mill, making

FIG 5

raw-bone meal. This mill is sometimes termed a *disintegrator*. In Fig. 5 the disintegrator is shown closed and in Fig. 6 it is shown open. A peculiarity of the bone mill is that the material is ground by impact on rounded iron bars and on itself. The open machine shows the revolving barred wheels. The inside wheel *a* revolves in the opposite direction from the outside one *b*, and both revolve at a very high rate of speed. As the bones are fed into the hopper, the revolving wheels keep them flying around until they are in a fine, dusty condition, when they pass through the bottom of the mill. The material is screened, and any pieces of bone that have escaped grinding are returned to the mill. If the grinding is carefully done, this, however, is seldom necessary.

FIG 6

After cooking, raw bone contains so much of the original substance that it is always necessary, previous to grinding, to crush the bone by means of a bone crusher, which is built on a plan similar to the ordinary rock or ore crusher. Raw-bone meal as produced in the packing house usually contains from 4 to 5½ per cent. of ammonia and from 20 to 25 per cent. of phosphoric acid.

**35. Steamed Bone and Ground Steamed Bone.** Bones that have been cooked under pressure are used for making steamed bone and ground steamed bone. All bones that are neither useful nor desirable for other purposes are made into steamed bone. They comprise rib bones, large knuckles, back bones, etc. From these bones are produced *butter-stock tallow* and *glue liquors*. For producing the latter, in connection with steamed bone, special cooking of the bones is necessary. When the bones are simply cooked for the tallow and residual bone, however, no special cooking is required.

**36. Cooking Bones for the Recovery of Tallow and Steamed Bone.**—In order to recover tallow and steamed bone, the bones are put into the rendering tank and cooked for from 7 to 10 hours at a steam pressure of about 40 pounds per square inch, which effectually removes the tallow from the bones. After a period of rest, to allow the tallow to rise, it is drawn off and the bones and water are dumped into a vat, from which any floating tallow remaining is removed. The water is drained away, as it seldom contains sufficient nitrogenous material to warrant the expense of evaporation for concentrated tankage. The cooked bones are very friable and porous. After draining on the floor for several hours, the bones are removed and made into piles. The heat generated in these piles is amply sufficient to dry the bones without passing them through a drier.

**37. Cooking Bones for the Recovery of Tallow, Glue Liquors, and Steamed Bone.**—The method of cooking bones for the production of glue liquors, together with the tallow, is carried out as follows:



The bones, which are loaded into a tank, are allowed to stand in water at a temperature of about 130° F. for 1 hour. This water is run off and, where beef extract is made, is used for this purpose. The bones are again covered with water and cooked for 6 hours with the tank uncovered. This is known as *open cooking*. The material is allowed to settle, and the resultant butter-stock tallow is drawn off. The cover is now put on the tank, and the bones are cooked for 2 hours under a pressure of 30 pounds per square inch. The glue liquor after settling is drawn off, more water is put on the bones, and a further pressure cooking of 3 hours is given, after which the tallow and glue liquor are drawn off. The material is now cooked at a pressure of 40 pounds per square inch for a few hours, when, after drawing off the tallow, the cooked bones are dumped from the tank into the vat underneath and treated as just described.

38. In Table I are given the results of tests on the boiling of rib bones. In test No. 1 the bones were boiled for the recovery of bone and tallow, and in test No. 2 the same material was boiled for the recovery of bone, tallow, and glue.

TABLE I  
RESULTS OF TESTS ON BOILING RIB BONES

Test	Dry Glue Per Cent.	Tallow Per Cent.	Dry, Steamed Bone Per Cent.
No. 1 . . . .	11.50	7.48	40.80
No. 2 . . . .	21.27	10.88	31.64

In Table II are given the partial compositions of analyses of the dry, steamed bone obtained in the preceding tests.

While the cooking for glue by this method consumes more time and is more laborious, the increased yield in the tallow obtained, together with the value of the glue liquor, makes it a more profitable method than cooking the bones for tallow and bones only.

The average steamed bone will analyze from 2 to 3 per cent. of ammonia and about 60 per cent. of bone phosphate. The dried, steamed bone is made into steamed-bone meal by grinding in the ordinary bone mill. For this purpose, the bones need not be previously crushed, as their brittle nature permits them to be very easily disintegrated.

**TABLE II**  
**PARTIAL COMPOSITIONS OF DRY, STEAMED BONE**

Test	Ammonia Per Cent.	Bone Phosphate Per Cent.	Fat Per Cent.
No. 1 . . .	3.66	59.21	7.67
No. 2 . . .	1.45	72.01	2.33

**39. Azotine.**—The material known as **azotine** is made from the residue of cooked cracklings, which, after being subjected to high pressure to extract all the grease possible, is passed through a drier and then ground fine. The material will shrink in weight from 35 to 40 per cent. in passing from the raw to the finished state, and loses at the same time several per cent. of ammonia. This material is not made in the large packing houses, but is derived mostly from small tallow and grease renderers. Azotine is sold on the unit basis of the ammonia it contains, that made from pork material containing about 2 per cent. more ammonia than that made from beef. Commercial azotine will analyze about 15 per cent. of ammonia on a basis of 10 per cent. moisture.

**40. Hoof Meal.**—Cattle hoofs are used for making **hoof meal**. The hoofs are cooked in the pressure tank for 5 hours at a pressure of about 40 pounds of steam per square inch, after which they are dried thoroughly. Care must be taken to have the cooked hoofs perfectly dry, for if they contain any appreciable moisture, it will be impossible to grind them. The dried hoofs are ground in the regulation bone-grinding mill to the fineness of bone meal. With the hoofs may also be placed useless horns, which also furnish hoof meal when

ground. This material contains a large amount of nitrogen, analyzing on a dry basis over 19 per cent. of ammonia. An analysis of hoof meal gave 2.1 per cent. moisture and 19.05 per cent. of ammonia.

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#### MIXED FERTILIZERS

**41.** For mixing fertilizers to make complete fertilizers, it is necessary to add to the bones and tankage other materials as diluents, and also some form of potash. The latter is most commonly commercial potassium chloride and at times potassium sulphate. The sulphate is regarded as preferable, especially for tobacco fertilizers. The diluents, or fillers, may be any cheap material, such as ashes ground fine or earth, or any more or less bulky material.

*Complete fertilizers* are materials that contain the elements necessary for the growth of organic matter, which are first extracted from the soil by growing crops. They comprise nitrogen (ammonia), phosphoric acid, and potash.

*Direct fertilizers* contain certain forms of plant food that contribute directly to the growth and substance of plants. Such materials may contain nitrogen, potash, or phosphoric-acid compounds, or any two, or all three, of these forms of plant food.

*Indirect fertilizers* are those which do not in themselves furnish directly to the soil any needed plant food, but whose chief value depends on the power they possess of changing unavailable forms of plant food into available forms. Indirect fertilizers include lime, gypsum, and salt.

**42. Ingredients of Mixed Fertilizers.**—Among the various and most common ingredients used in making complete fertilizers are dried blood, tankage, cottonseed meal, azotine, bones, potassium chloride, potassium sulphate, sodium nitrate, ammonium sulphate, and various forms of phosphates derived principally from phosphate rock.

*Tankage*, containing, as it ordinarily does, from 7 to 10 per cent. of ammonia, is in too concentrated a form to be used by itself as a fertilizer and at the same time is too

expensive. Although, as a rule, there is no objection to using tankage in its natural state, it lacks potash, which is a very essential ingredient in a commercial fertilizer.

*Bone*, in the form of raw-bone meal, is used for a direct fertilizer. But the objection to using this material is the insoluble form of most of the phosphoric acid it contains.

A source of nitrogen frequently used in complete fertilizers is found in *sodium nitrate*, or *Chile saltpeter*, which contains about 15½ to 16 per cent. of nitrogen. This is ordinarily used in connection with the phosphates, tankage, and other nitrogenous materials, such as bones. The disadvantage of using sodium nitrate is its free solubility in water, thereby washing out of the soil too readily. It is adaptable, however, for crops that mature in a short growing period.

Of late years, owing to the constantly growing demand for nitrogenous material, *cottonseed meal* has been very extensively employed in the making of fertilizers. This material is comparatively cheap and is always available in steady quantities. It furnishes an excellent raw material, containing about 7 or 8 per cent. of ammonia.

*Phosphate rock* is a mineral phosphate found in various states. In a raw condition, it contains from 25 to 35 per cent. of phosphoric acid. This acid, however, is in an insoluble condition and, consequently, must be treated with sulphuric acid before the phosphates can be made available. The quantity of acid required varies with the amount of phosphates present, which has to be determined by analysis in the usual way. (See *Quantitative Analysis*.)

*Acid phosphates* are known under various names, such as superphosphates, dissolved rock, etc. They are formed by treating bones, bone black, bone ash, etc. with sulphuric acid. By such treatment there are formed soluble phosphates of calcium and calcium sulphate (gypsum) in nearly equal proportions. All forms of bone products are valuable fertilizers, as they furnish phosphoric acid and also ammonia.

*Discarded bone black* from sugar refineries also furnishes a source of fertilizer material. This bone black, however, contains no nitrogen.

*Garbage tankage* also contributes very largely to fertilizer material, this being its only use.

*Ammonium sulphate* is a by-product from the manufacture of illuminating gas or coke. There are occasions, however, when its high price prevents it from being used in commercial fertilizers.

*Potassium salts*, such as kainite, kaiserite, etc., used in the manufacture of fertilizers, are obtained principally from the Stassfurt mines. The potassium chloride, known commercially as muriate of potash, generally contains from 50 to 53 per cent. of actual potash. Potassium sulphate from this source ordinarily contains from 48 to 51 per cent. of actual potash.

*Fish scrap* is also used extensively in fertilizers.

**43. Mixing the Ingredients.**—The raw materials just described are mixed in various proportions, depending on the use of the fertilizer for certain crops and also on the sale price of the finished product. All materials should be in a finely ground condition, as, in addition to its chemical composition, the mechanical condition of a fertilizer is an important consideration, the degree of pulverization or fineness controlling to a great extent the rate of solubility of the different ingredients.

The mixing of the various ingredients is merely a mechanical operation, and is most commonly done with some form of fertilizer mixer. It is very essential that the several ingredients be thoroughly incorporated with one another. The most common form of mixer consists of a shallow, revolving pan, in which is placed apparatus for mixing the fertilizer while the pan is revolving. Any form of mixer that will fill the requirements of thorough incorporation may be used for this purpose. With small quantities, mixing can be accomplished by numerous siftings and subsequent hand mixing; this method is serviceable for experimental laboratory mixtures. Mechanical mixers that are capable of mixing from 10 to 150 tons of fertilizer every 10 hours can be procured.

**44. Formulas for Fertilizer Mixtures.**—Each manufacturer has his own formula for making fertilizer. A few formulas will suffice to show the general method of combining the ingredients. For a fertilizer adapted for wheat and grass, the following mixture is made:

	POUNDS
Steamed bone . . . . .	1,200
Potassium chloride . . . . .	45
Filler . . . . .	755
Total . . . . .	2,000

An analysis of this mixture will be about as follows:

	PER CENT.
Ammonia . . . . .	2 to 2.5
Available phosphoric acid . . . . .	8 to 10.0
Potash . . . . .	1 to 2.0

Another mixture is as follows:

	POUNDS
Steamed bone . . . . .	900
Tankage (low grade) . . . . .	190
Potassium chloride . . . . .	210
Filler . . . . .	700
Total . . . . .	2,000

An analysis of this is about as follows:

	PER CENT.
Ammonia . . . . .	2 to 3
Available phosphoric acid . . . . .	8 to 9
Potash . . . . .	5 to 6

A mixture made for a potato fertilizer is compounded with the following ingredients:

	POUNDS
Steamed bone . . . . .	1,000
Sodium nitrate . . . . .	212
Tankage (low grade) . . . . .	150
Potassium chloride . . . . .	365
Filler . . . . .	273
Total . . . . .	2,000

This mixture will analyze as follows:

	PER CENT.
Ammonia . . . . .	4 to 5
Available phosphoric acid . . . . .	7 to 8
Potash . . . . .	9 to 10

A so-called "guano" is made from the following formula:

	POUNDS
Steamed bone . . . . .	570
Sodium nitrate . . . . .	200
Tankage . . . . .	900
Potassium chloride . . . . .	330
Total . . . . .	2,000

This mixture makes a very high-grade fertilizer, containing no filler. It analyzes about as follows:

	PER CENT.
Ammonia . . . . .	6 to 7
Available phosphoric acid . . . . .	5 to 6
Potash . . . . .	8 to 9

A mixture composed of

	POUNDS
Bone meal . . . . .	400
Dissolved bone black . . . . .	400
Dried blood . . . . .	300
Sodium nitrate . . . . .	200
Dissolved phosphate rock . . . . .	350
Potassium chloride . . . . .	350
Total . . . . .	2,000

was found to give, on analysis,

	PER CENT.
Nitrogen . . . . .	4.09
Available phosphoric acid . . . . .	9.59
Insoluble phosphoric acid . . . . .	2.50
Potash . . . . .	9.62

Most fertilizers are sold under their special brand and their makers' names, and nearly all states in the United States

have stringent laws governing the sale of fertilizer. These laws require that licenses be procured, registration of brands be made, analysis of the material be submitted, etc. They also require that a statement as to the guaranteed analysis be printed on the bags in which the material is sold.

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## ANALYTICAL METHODS AND TESTS OF PRODUCTS

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### DETERMINATION OF GRADE OF OILS, TALLOWES, GREASES, ETC.

45. The following analyses and tests, together with those referred to in *Quantitative Analysis* on the analysis of fats and also those on the examination of fertilizers, cover the most important methods used in packing-house laboratories.

46. **Determination of Melting Point of Fats.**—Many methods have been devised for ascertaining the melting point of fats, but none of them has given entirely satisfactory results in all cases. Among the best methods are those described by Wiley, in "Principles and Practice of Agricultural Analysis." The method adopted by the official agricultural chemists will be described, together with a method modified by Hebner and Angell, which has been found to give very satisfactory results where several samples of the same class of material are to have their melting points determined. The Hebner and Angell method will be found particularly applicable to butters and butterines.

47. **Sinking-Point Method of Hebner and Angell.** The Hebner and Angell method is carried out in the following manner: A small pear-shaped float is blown from a piece of glass tubing and made about 1 centimeter in diameter and 2 centimeters long. The stem of the pear is



drawn out and broken off, and while the bulb is still warm, the open end of the stem is held in mercury. A small quantity of this substance, sufficient in amount to cause the float to sink slowly through a melted fat, is introduced into the bulb of the apparatus and the stem sealed. The whole bulb should displace about 1 cubic centimeter of liquid and should weigh, with the mercury, about 3.4 grams.

In conducting the experiment, about 30 grams of the dry, melted fat is placed in a large test tube and cooled by immersing the tube in water at a temperature of 15° C. The tube containing the solidified fat is placed in a bath of cold water, and the sinker is placed in the center of the surface of the fat. The bath is then slowly heated until the float disappears. The temperature of the bath is read just as the bulb of the float disappears.

**48. Wiley's Method.**—Wiley's method of determining the melting point of fats has been adopted by the official chemists. It depends on the fact that a disk of fat when floating in suspension in a liquid assumes a spheroidal form when melted. The method is described by Wiley as follows:

In the preparation of the apparatus there are required (1) a piece of ice floating in distilled water that has been recently boiled and (2) a mixture of alcohol and water of the same specific gravity as the fat to be examined. This is prepared by boiling distilled water and 95-per-cent. alcohol for 10 minutes, to remove the gases that they may hold in solution. While still hot, the water is poured into a test tube, described later, until it is almost half full. The test tube is then nearly filled with the hot alcohol, which is carefully poured down the side of the inclined tube to avoid too much mixing. If the alcohol is not added until the water has cooled, the mixture will contain so many air bubbles as to render it unfit for use. These bubbles will gather on the disk of fat as the temperature rises and finally force it to the top.

The apparatus for determining the melting point is shown

in Fig. 7, and consists of an accurate thermometer *a*, for determining the melting point, reading easily tenths of a degree (it is advisable to use a cathetometer for reading the thermometer, but this may be done with an eye glass if held steadily and properly adjusted); a thermometer *c* for regulating the temperature of the bath; a beaker *d* 35 centimeters high and 10 centimeters in diameter; a test tube *e* 30 centimeters long and  $3\frac{1}{2}$  centimeters in diameter; a stand *f* for supporting the apparatus; and some device for stirring the water in the beaker (for example, a blowing bulb *g* of rubber and a bent glass tube extending almost to the bottom of the beaker).

The disks of fat are prepared as follows: The melted and filtered fat is allowed to fall from a dropping tube, from a height of about 20 centimeters, on a smooth piece of ice floating in recently boiled distilled water. The disks thus formed are from 1 to  $1\frac{1}{2}$  centimeters in diameter and weigh about 200 milligrams. By pressing the ice under the water, the disks are made to float on the surface, from which they are easily removed with a steel spatula, which should be cooled in the ice water before using. The disks must be allowed to stand for 2 or 3 hours in order to obtain the normal melting point.

FIG. 7

The test tube containing the alcohol and water is placed in a tall beaker containing water and ice and left there until cold. The disk of fat is then dropped into the tube from the spatula, and at once sinks until it reaches a part of the tube where the density of the mixture of alcohol and water is exactly equivalent to its own. Here the disk remains at rest and free from the action of any force save that inherent in its own molecules.

The delicate thermometer *a* is placed in the test tube and then lowered until the bulb is just above the disk. In order to secure an even temperature in all parts of the alcohol mixture, in the vicinity of the disk, the thermometer is gently moved from time to time in a circularly pendulous manner.

The disk having been placed in position, the water in the beaker is slowly heated and kept constantly stirred by means of the blowing apparatus *g* already described. When the temperature of the alcohol-water mixture rises to about 6° C. below the melting point, the disk of fat begins to shrivel and it gradually rolls up into an irregular mass.

The thermometer is now lowered until the particle of fat is even with the center of the bulb. The bulb of the thermometer should be small, so as to indicate only the temperature of the mixture near the fat, and a gentle rotatory movement should be given to the thermometer bulb. The rise of temperature should be so regulated that the last 2° C. of increment requires about 10 minutes. The mass of fat gradually approaches the form of a sphere, and when it is sensibly so, the reading of the thermometer should be made. As soon as the temperature is taken, the tube is removed from the bath and again placed in the cooler. A second tube containing alcohol and water is at once placed in the bath. The test tube (ice water having been used as a cooler) is of low enough temperature to cool the bath sufficiently. After the first determination, which should be only a trial, the temperature of the bath should be so regulated as to reach a maximum of about 1.5° C. above the melting point of the fat under examination.

The edge of the disk of fat should not be allowed to touch the sides of the tube. This accident rarely happens, but in case it should take place and the disk adheres to the sides of the tube, a new trial should be made.

Triplicate determinations should be made, and the second and third results should agree closely.

In this connection, with the determination of melting points, the melting point of waxes in *Quantitative Analysis* should be referred to. The methods there described are also applicable in some cases to fats, but the method just explained has met with much success and approval. For rapid determinations with a large number of samples, however, the method of Hebner and Angell is to be preferred.

**49. Determination of Tallow in Lard.**—It is frequently of importance to have a rapid method of ascertaining whether or not a lard is adulterated with beef fats. While a large proportion of the latter would be made evident to the practical chemist by the altered physical characteristics of pure lard, yet an admixture of a small percentage of tallow or oleo stearin might easily pass unnoticed.

**50. Wesson's Method for Tallow in Lard.**—David Wesson has devised a ready method of determining small quantities of tallow, which, while not exact in the scientific sense, is so eminently practical, rapid, and easily applicable in the packing house that it is relied on to give approximate results. It is obvious that the results obtained by this method must be confirmed by further investigation, iodine number, etc., where the result is of importance in legal cases, disputes, etc., but for the matching or duplicating of a lard for trade purposes, other than domestic, the method has great value and utility.

All fats in a state of fusion a little above their melting points, may be considered as solutions of their solid glycerides in the liquid oils or the oleins. For example, cotton-seed oil at ordinary temperatures contains from 20 to 25 per cent. of solid glycerides, which crystallizes out as stearin.

When the oil is chilled and at a temperature of  $0^{\circ}$  C., the oil becomes a solid fat. In like manner, prime steam lard at  $32^{\circ}$  C. is a clear oil from which its solid glycerides crystallize on cooling, until at  $25^{\circ}$  C. the lard becomes a solid fat. Prime steam lard contains about 35 per cent. of solid glycerides and about 65 per cent. of olein, which holds the glycerides in solution at  $30^{\circ}$  to  $32^{\circ}$  C., and in some instances lower.

The solid glycerides from tallow are far less soluble in olein than those from lard and crystallize out at much higher temperatures. Owing to this fact, it is possible to detect with ease and certainty the solid glycerides of beef fat, namely, oleo stearin, when it exists in lard in quantities of 5 per cent. and upwards.

**51.** Wesson's process, which is very simple, is carried out as follows:

First, determine the titer of the fat under examination. The Dalican titer or crystallization temperature of the fatty acids indicates, approximately, the proportions of liquid and fluid acids present.

Second, prepare with materials of known purity—prime lard and prime-lard stearin—a mixture that will possess about the same titer as the sample. Pour some of the melted standard into one test tube and a like quantity into another; at the same time have another test tube that contains a mixture of lard hardened to the same titer with oleo stearin. All the tubes are now brought to the same temperature in a beaker of hot water and immersed in a bath of water at about  $35^{\circ}$  C. As the bath cools down, the tubes are watched from time to time and the temperatures and times at which they deposit crystals and their manners of crystallization are noted.

If the sample under examination consists of pure lard stock, it will cool in a manner similar to the standard mixture. If oleo stearin is present, the sample will deposit crystals, or become cloudy sooner and at a higher temperature than the standard, and comparison with the samples

prepared with oleo stearin will show the approximate percentage, which will be confirmed by the Dalican titer, taking into consideration the approximate amount of cottonseed oil that may be present. The manner of cooling is quite characteristic. Pure lard stock generally forms comparatively large stellate, or starlike, bundles of crystals, while those from oleo stearin are very small, and appear as a cloud. A few trials with mixtures of known composition will make these appearances familiar and unmistakable.

It is of the utmost importance that the lards should be dry and clear, as moisture will cause a lard to cloud above its normal temperature. With this test, soft tallow and oleo-margarine, having not too low melting and cooling points on account of the excess of olein in them, give the indications of quantities of oleo stearin proportional to their hardness; and in some cases where the flavor and appearance of the sample indicate tal-

FIG. 8

low, rather than oleo stearin, it is the custom to report tallow equivalent to so much oleo stearin.

With lards of comparatively high titer and consequently high cooling point, it is necessary to consider the effect of lard stearin on the titer when calculating the probable composition. Ten per cent. of oleo stearin mixed with pure lard will deposit crystals and show cloudiness before a mixture of 50 per cent. of lard and 50 per cent. of lard stearin.

**52.** The arrangement of the apparatus used for this determination is shown in Fig. 8. A beaker *a* having a capacity of about 750 cubic centimeters is covered with a piece of thin wood, cardboard, or metal *c*. This cover is provided with a circular aperture, through which passes a smaller beaker *b*. The cover *c* is provided with orifices for a number of test tubes *l*, which contain the samples and standards of comparison. A thermometer *t* serves to indicate the temperature in the beaker *b*. The inner beaker *b* is filled with water up to the point marked *w*, which should be a little above the surface *w'* of the melted lards.

**53. Determination of Unsaponifiable Matter in Oils, Etc.**—In order to determine the amount of unsaponifiable matter, 10 grams of lard or oil is accurately weighed off in a porcelain dish and saponified with alcoholic potash. The solution is evaporated on a water bath to dryness, moistened when dry with methyl alcohol, and again evaporated to dryness. The soap is dissolved to a clear solution with distilled water, and this solution is shaken out in a separatory funnel with light boiling gasoline or rhigolene. The gasoline is retained in the separatory funnel by running off the watery, underlying solution.

The gasoline remaining in the funnel is washed several times with water, to remove any dissolved soap, and finally it is withdrawn into a weighed cup or flask. The gasoline is either distilled or evaporated off, and, after drying for 2 hours at 100° C, the receptacle and its contents are weighed. The increase in weight divided by the amount of substance taken, and this result multiplied by 100, will give the percentage of unsaponified matter present in the oil or fat. In connection with this determination, reference should be made to *Quantitative Analysis*. The method there described combined or used in connection with the foregoing will enable an adulteration of animal oils with mineral oils to be detected.

**54. Cold Test of Animal Oils.**—The cold test is a trade requirement with most animal oils. The sample of oil must

be thoroughly mixed, to insure uniformity. If the oil is frozen or chilled, it must be warmed and melted to a uniform consistency. The test is made as follows:

About 1 ounce of the oil to be tested is put into a common 4-ounce sample bottle, and in the oil is placed a short, stout thermometer. The bottle is then placed in a situation where the oil will become frozen; if necessary, a freezing mixture is used. (In connection with this test, see *Quantitative Analysis* under the heading Cloud Test in Mineral Oils.) When the liquid has become solid throughout, the bottle is removed from the cold and the oil allowed to soften. At the same time the oil is thoroughly stirred and mixed with the thermometer, until the mass will run from one end of the bottle to the other. The neck of the bottle is now grasped by one hand, which should hold some waste or a towel to enclose the thermometer. The latter is withdrawn through the waste or towel, so as to wipe far enough to see the mercury, and the temperature is observed. The reading is the cold test of the oil.

**55. Determination of Free Fatty Acids in Oils, Tallows, Etc.**—To ascertain the amount of free fatty acids in oils, etc., a supply of neutralized alcohol is made by dissolving in ordinary alcohol a small quantity of phenol phthal-ein and cautiously adding, drop by drop, a weak solution of alkali until, after persistent shaking, the alcohol retains a faint pink color. All free acid is now neutralized.

A known weight of oil or fat is placed in an ordinary 4-ounce sample bottle, and to it is added 50 or 60 cubic centimeters of the neutralized alcohol. The whole is then shaken and heated on the water bath for 15 to 20 minutes or until hot. If the sample is wholly free from acid, the pink color of the alcohol remains unchanged. If free acid is present, the alcohol becomes decolorized. A seminormal solution of caustic soda is now carefully added until, after successive shakings, the pink color returns to the alcoholic solution. The reaction is very sharp, and the end point, with all material except very dark oils or greases, is well



defined. When testing the latter, a much larger quantity of alcohol is used, and the solution after each shaking is allowed to settle. In this way, the color of the underlying solution may more easily be observed.

**56.** In ordinary practice, it is customary to consider the free acid present in oils and fats as oleic acid, although this may not actually be the case. The molecular weights of oleic and stearic acids are not so widely different that the result is materially affected. For example, 1 cubic centimeter of seminormal caustic solution corresponds to .142 gram of stearic acid or to .141 gram of oleic acid.

For oils of average grade, 10 grams is usually taken for the test. For material containing very little free acid, the quantities taken for the test must be correspondingly increased to obtain an accurate result. For poor tallows, from 20 to 25 grams is generally taken. For good tallows and oleo stearins, 50 grams is taken for the test.

**57. Detection of Cottonseed Oil in Oil and Lard.** Many methods are in use for the purpose of detecting adulterations of various products with cottonseed oil. While it is not advisable to rely entirely on any one test, that of Milliau has been used with good results in the packing-house laboratory. This method depends on the darkening of the fatty acids of cottonseed oil by the action of nitrate of silver on them. The fatty acids of pure lard or olive oil are not discolored by the action of nitrate of silver. The process as performed by Milliau follows:

In a porcelain dish having a capacity of 250 cubic centimeters, 15 cubic centimeters of the substance to be tested for the presence of cottonseed oil is heated to 110° C. Then, on the oil is poured a mixture of 10 cubic centimeters of sodium hydrate, 36° Baumé, with 10 cubic centimeters of 90-per-cent. alcohol. While the heated mass is still limpid and homogeneous, 150 cubic centimeters of hot distilled water is added, and the mixture is heated to drive off the alcohol. This requires only a short time. The solution is now decomposed with  $\frac{1}{10}$  normal sulphuric acid to acid

reaction. The fatty acids are immediately removed with a platinum spatula and washed two or three times with cold distilled water. They are then placed in a test tube ( $2\frac{1}{2}$  centimeters by 9 centimeters), and 15 cubic centimeters of 92-per-cent. alcohol and 2 cubic centimeters of a 3-per-cent. solution of nitrate of silver are added.

The test tube with its contents is placed in a water bath at  $90^{\circ}$  C. and about one-third of the alcohol evaporated, when 10 cubic centimeters of distilled water is added, the heating continued a few minutes longer, and the coloration of the fatty acids noted. In the absence of cottonseed oil the acids remain perfectly white; while if cottonseed oil is present, the depth of color will depend on the amount of cottonseed oil present in the substance.

**58. Halpen's Reaction for Cottonseed Oil.**—The Halpen test is more sensitive than the Bechi test (see *Quantitative Analysis*) and is less likely to give unsatisfactory results in the hands of an inexperienced person. It is not affected by rancidity, which in a test is of great importance at times. The depth of color is proportional to a certain extent to the amount of oil present, and by making comparative tests with cottonseed-oil mixtures of known proportions, some idea of the amount present in a mixture of oils under examination can be obtained. It should be remembered, however, that different oils react with different intensities, and cottonseed oils that have been heated to from  $200^{\circ}$  to  $210^{\circ}$  C. react with greatly diminished intensity. Heating 10 minutes at  $250^{\circ}$  C. renders cottonseed oil incapable of giving reaction.

Lard and lard oil from animals fed on cottonseed meal will give a faint reaction, as will also the fatty acids.

The Halpen test is made as follows: Carbon bisulphide containing about 1 per cent. of sulphur in solution, is mixed with an equal volume of amyl alcohol. Equal volumes of this reagent and the oil under examination are then mixed and heated in a bath of boiling saturated brine for from 1 to 2 hours. In the presence of as small an amount as

1 per cent. of cottonseed oil, an orange or a red color is produced, which is characteristic.

In the Bechi, or silver-nitrate, test for cottonseed oil, rancid oils or fats must first be purified before testing, a condition that Halpen's test does not require.

In connection with the two preceding tests, those described in *Quantitative Analysis* should also be applied. When any single test fails to give results of a most decisive character regarding adulteration, all tests applicable should be applied to the lard, fat, or oil under consideration. Taking all the results together, the absence or presence of cottonseed oil or other adulteration may be determined with comparative certainty.

**59. Examination for Impurities in Solid Fats, Oils, Etc.**—The subject of examination for impurities in solid fats, oils, etc. is covered fully in *Quantitative Analysis*, and further methods under the examination of waxes, also treated there, may be applied to these substances. It may be said that if one test is to be preferred over another for an examination of purity in lard, it should be that of the Hübl iodine number, which is carried out as directed in *Quantitative Analysis*.

**60. Dalican Test for Determining the Titer of Tallow and Stearin.**—The determination of the titer of a fat is to ascertain the temperature, expressed in degrees centigrade, at which the free fatty acids extracted from a fat solidify. This test is also called the *hardness*, or *freezing-point, test*. Animal fats consist largely of the glycerides of oleic, stearic, and palmitic acids. Almost every animal fat contains a small percentage of free fatty acid, together with a smaller or larger percentage of impurities.

The determination of the solidifying temperature of the fatty acids of a given fat requires, first of all, that the fatty acids be extracted from the fat and separated from the glycerine, combined with which they form, as glycerides, the bulk of the fat. In order to obtain the free fatty acids, it is necessary to follow a roundabout method, as it is impossible to separate the fatty acids from the glycerine directly, except

by subjecting the fat to a degree of heat and pressure and the action of a relatively smaller quantity of chemicals, which are liable to cause changes in the free fatty acids.

When an animal fat is treated and heated with a sufficient quantity of some strong alkali, such as caustic soda or caustic potash, the glycerides are decomposed; the alkali unites with the free fatty acids, thereby forming soap and liberating the glycerine. The soap formed when treated with a stronger mineral acid, such as hydrochloric or sulphuric acid, is decomposed. The hydrochloric or sulphuric acid, combining with the alkali of the soap, leaves the free fatty acid as an oily layer floating on top of the hot aqueous solution of the other constituents. To separate this oily layer, the aqueous solution may be drawn off from beneath the fatty acid or the entire mass may be cooled, when the fatty acids will congeal, forming a solid cake, which can be removed from the aqueous solution. By washing the free fatty acids with distilled water, the adhering traces of mineral acid, etc. are removed; by a subsequent drying, all the adhering water is removed, and the fatty acids are obtained free from any of the substances originally combined with or added to them in the course of separation.

**61.** It is absolutely necessary to extract all the fatty acids from the fat and to have no fatty acids in combination with glycerine left in the free fatty acids, the solidifying temperature of which is to be determined. In order to be sure that no such glycerides remain mixed with the fatty acids, it is necessary to saponify the fat completely; that is, to unite all the fatty acids existing in the fat with the alkali. To insure and facilitate the completeness of saponification, alcohol is added when the fat is heated with the strong caustic alkali. The presence of alcohol accelerates the action of the caustic, and under proper conditions insures complete saponification. The alcohol may, however, cause an error if it is not completely removed by evaporation before the soap formed is decomposed by mineral acid. If alcohol is present in the soap when the mineral acid is added, the free fatty

acid may combine with such alcohol and form a substance that, mixed with the free fatty acid, will reduce the solidifying temperature of the fatty acid.

Any glycerides left in the fatty acids will also have the same effect. It is therefore absolutely necessary to obtain complete saponification and to drive off all the alcohol from the soap formed before such soap is decomposed by a stronger acid. When, with the exception of water, the fatty acids are separated from all the other substances, there only remains the freeing of the fatty acids from the water before they can be tested as to their solidifying point. It has been demonstrated that the manner in which this water is removed may materially influence the solidifying point. The titer is .5° higher when the fatty acids are previously heated for 2 hours at 100° C. than when such heating is not done, or done only for a considerably shorter time.

Bulletin No. 13 of the United States Department of Agriculture, Division of Chemistry, 1889, gives the official method of the Dalican test as practiced by the government chemists; but while it gives minute details for ascertaining the solidifying point of the fatty acids, it fails to give directions as to the manner of separating the fatty acids from the fat. To this lack of definite directions may be attributed some of the differences in results obtained by different chemists.

The method for the titer test adopted by the Association of Official Agricultural Chemists, as provisional, is described in Circular 27, Bureau of Chemistry (Department of Agriculture).

**62.** For the preparation of the soap and thereafter the free fatty acids from tallow, etc., the original Dalican saponification method is usually preferred. Dalican proposed to heat 50 grams of tallow, etc. to a temperature of 200 C., and to pour into the hot tallow a mixture of 40 cubic centimeters of caustic soda, specific gravity 1.33, and 33 cubic centimeters of 95-per-cent. alcohol, while constantly shaking or stirring the mass. This operation is usually carried on in an enameled-iron dish. In heating the oil in such a dish to

200° C., a sufficient amount of heat is stored in the dish to drive off all or most of the alcohol and to produce an almost dry, crumbly soap, which is then dissolved in boiling water and decomposed by mineral acid.

For this purpose, 150 cubic centimeters of dilute sulphuric acid (specific gravity 1.143) will be sufficient. The fatty acids rise to the top of the liquid in pasty, flocculent masses. The liberated fatty acids are then boiled until they appear on the top of the liquid as a clear, oily layer. The entire mass is then transferred to a separatory funnel. The aqueous underlying solution is next drawn off, and the fatty acids are washed with very dilute, hot sulphuric-acid solution, and then with hot water, until the wash water gives no acid reaction. The fatty acids are then transferred to a beaker and dried for 2 hours at 100° C.

In the determination proper, the following apparatus is employed: A thin-walled test tube (1.4 inches by 6 inches) is fixed by means of a cork in a suitable bottle. A centigrade thermometer, reading from 1° to 60° and graduated in  $\frac{1}{10}$  degrees, is fixed in the test tube by a second cork, which must be sufficiently loose to permit the contents of the tube to be stirred easily with the thermometer. If, in its manufacture, the stem of the thermometer is shortened by blowing an enlargement in the bore between 1° and 25°, the amount of mercury above the surface of the fatty acids is thus diminished and a very appreciable error consequently avoided.

The test tube is filled with the decanted and dry fatty acids from the beaker to within  $\frac{1}{2}$  or  $\frac{3}{4}$  inch from the top. The thermometer is inserted into the liquid to about the 35° mark, and the liquid fatty acids are stirred until they become quite opaque and partial solidification sets in. The thermometer should clear the bottom of the tube by about  $1\frac{1}{2}$  or 2 inches, and in order to protect the bottom of the tube from cold surfaces, on which it may rest, a wad of cotton should be placed in the bottom of the outer bottle.

After stirring rapidly in a circle ten or twelve times, the thermometer is allowed to rest. The mercury now begins

to rise in consequence of the latent heat liberated from the solidifying fatty acids, and the highest temperature noted is taken as the solidifying point, or titer, of the fatty acids. The mercury will remain stationary at this point for several minutes, after which it drops again. Each titer test should be repeated, and the difference between the two should not exceed  $.1^{\circ}$  C.

The titer of a fat is synonymous to *hardness*; the former term is used in Europe in preference to the term hardness employed in the United States. The determination is a very simple operation, yet the slightest deviation from the established rules and the seemingly most unimportant external influences, such as a draft in the room, will influence the result to the extent of several degrees. It is also essential to be sure of complete saponification; a hundredth of one per cent. of fat left unsaponified in the operation sometimes means a degree of hardness, more or less.

**63.** The method of making the titer test given in *Quantitative Analysis*, while similar to the foregoing, requires much more time to perform. In addition to this, the manner of stirring the fatty acids exercises a great influence on the result. With the method just given the complete operations for the titer can be performed in about 3 hours; it is practiced in both packing houses and commercial laboratories, yielding quick and, at the same time, accurate results.

Table III is an empirical table compiled by Dalican, giving the percentages of stearic and oleic acids present in tallows yielding fatty acids of the solidifying points shown. The total yield of fatty acids is taken as 95 per cent.

**64. Determination of Moisture in Tallow, Grease, Etc.**—The amount of moisture in tallow, grease, etc. together with the titer, or hardness, is the basis of commercial transactions in these articles. For the determinations, 20 grams of the average sample is weighed into a weighed porcelain dish. A small glass stirring rod is also weighed with the empty dish. The dish with the material and

rod is placed on the water bath and heated, with occasional stirring, for 2 hours. It is then cooled in the desiccator and weighed. The loss in weight is the moisture contained in the sample. To insure accuracy, the material is again heated and occasionally stirred for  $\frac{1}{2}$  hour longer, when it is again cooled and weighed. If no further loss in weight is observed, the grease or tallow is *dry* and all moisture has been driven off. The loss in weight multiplied by 100 and divided by the weight of the sample taken will give the percentage of moisture.

**65. Determination of Impurities in Tallow, Grease, Etc.**—The weighed material from the moisture determination is now dissolved in cold carbon bisulphide and filtered through a previously dried, weighed filter. The dish and rod are thoroughly rinsed by washings into the filter. These washings remove from the dish and rod all particles of foreign matter, which must be weighed as impurities. The filter is washed by successive additions of carbon bisulphide until thoroughly free from greasy matter, when the filter, with the funnel, is placed in the drying oven for about  $\frac{1}{2}$  hour. The detached filter containing the impurities is then weighed. The increase in weight gives the amount of impurities in the 20 grams of material taken for test. This multiplied by 100 and divided by 20 will give the percentage in the material. The impurities are reported as "impurities insoluble in cold carbon bisulphide," and usually consist of lime, soap, and extraneous dirt.

Rhigolene may also be employed in this determination, being used in the same manner as carbon bisulphide. In this case, the impurities obtained are simply reported as "impurities."

In the preceding determinations, it is always necessary to eliminate moisture before the impurities can be ascertained. If this is not done, serious difficulty will be met, as the moisture in the material will wet the filter paper, and thus prevent the carbon bisulphide or the rhigolene from passing through.



**66. Results of Tests on Products.**—The results given in Table IV were obtained in the packing-house laboratory on various products made, and on the cottonseed oils, for purposes of comparison. They may be regarded as regular, average results on the substances as produced in the packing house.

The results regarding “lard compound” are those obtained with that article *as then made*; that is, with no lard whatever in its composition, as explicitly set forth in the table.

#### ANALYTICAL PROCESSES AND TESTS FOR FERTILIZERS

**67.** As previously mentioned, there are many tests and analyses made daily in the packing-house laboratories that, although not absolutely accurate, are sufficiently so to enable an immediate check, if necessary, to be placed on the various operations. There are many more or less crude and loose methods by which very rapid approximate results are obtained. It must be remembered, however, that these are for comparative and control results only, and are not intended for comparisons with accurate and commercial analyses made on the same materials by outside chemists.

When exact results are desired, the analyses must be made by the most approved and accurate methods, and all loose or approximate working must be entirely eliminated from the operations. An example of this is when tankage or blood is sold on the basis of units of ammonia. While, for control results, it is immaterial, for example, whether the tankage contains 9.85 or 10.1 per cent. of ammonia, it is of the utmost importance, in selling, that the exact percentage of ammonia be known, as often the sale of perhaps many carloads may depend on this percentage.

Again, for control purposes, all that it may be necessary to ascertain is whether or not a tallow possesses a titer of at least 42°; but for sale purposes, where the price of the product is regulated by the exact hardness, the most accurate determination of the titer must be made as a check on the

**TABLE III**  
**PERCENTAGE OF STEARIC AND OLEIC ACIDS IN TALLOW**

Titer, or Solidifying Point		Stearic Acid Per Cent.	Oleic Acid Per Cent.
C.	F.		
35.0	95.0	25.20	69.80
35.5	95.9	26.40	68.60
36.0	96.8	27.30	67.70
36.5	97.7	28.75	66.25
37.0	98.6	29.80	65.20
37.5	99.5	30.60	64.40
38.0	100.4	31.25	63.75
38.5	101.3	32.15	62.85
39.0	102.2	33.14	61.55
39.5	103.1	34.30	60.80
40.0	104.0	35.15	59.85
40.5	104.9	36.10	58.90
41.0	105.8	38.00	57.00
41.5	106.7	38.95	56.05
42.0	107.6	39.90	55.10
42.5	108.5	42.75	52.27
43.0	109.4	43.70	51.30
43.5	110.3	44.65	50.35
44.0	111.2	47.50	47.50
44.5	112.1	49.40	45.60
45.0	113.0	51.30	43.70
45.5	113.9	52.25	42.75
46.0	114.8	53.20	41.80
46.5	115.7	55.10	39.90
47.0	116.6	57.95	37.05
47.5	117.5	58.90	36.10
48.0	118.4	61.75	33.25
48.5	119.3	66.50	28.50
49.0	120.2	71.25	23.75
49.5	121.1	72.20	22.80
50.0	122.0	75.05	19.95
50.5	122.9	77.10	17.90
51.0	123.8	79.50	15.50
51.5	124.7	81.90	13.10
52.0	125.6	84.00	11.00
52.5	126.5	88.30	6.70
53.0	127.4	92.10	2.90

**TABLE IV**  
**RESULTS ON TESTS OF PRODUCTS**

Product	Titer Degrees C.	Iodine No.
Crude cottonseed oil ( <i>for comparison</i> ) . .	35.05	110.42
Prime summer-yellow cottonseed oil . .	36.65	106.52
Treated cottonseed oil (heated and blown somewhat) . . . . .	37.05	105.11
White (bleached) cottonseed oil . . . .	36.45	106.70
Cottonseed stearin . . . . .		95.58
Lard compound (75 per cent. cottonseed oil, 25 per cent. oleo stearin) . . . . .	38.85	83.33
Lard compound (75 per cent. cottonseed oil, 15 per cent. oleo stearin, 10 per cent. tallow) . . . . .	38.00	88.56
Lard compound (80 per cent. cottonseed oil, 20 per cent. oleo stearin) . . . . .	38.01	86.20
"Cotto" compound (cottonseed oil and tallow) . . . . .	38.15	71.94
Lard (manipulated) . . . . .	39.35	67.77
Lard (manipulated) . . . . .	37.60	84.41
Prime steam lard (unbleached) . . . . .	38.65	64.85
Prime steam lard (old lard—pure) . . . .	38.51	62.11
Prime steam lard (bleached) . . . . .	39.00	63.31
Prime refined lard . . . . .	38.45	64.63
Pure leaf lard . . . . .	40.50	57.39
Oleo stearin (bleached) . . . . .	50.65	23.68
Lard stearin (bleached) . . . . .	43.45	52.18
Tallow stearin (bleached) . . . . .	46.45	64.07
No. 1 tallow . . . . .	42.95	
No. 2 tallow . . . . .	42.48	
Butter-stock tallow (bleached) . . . . .	43.25	43.87
Mutton tallow . . . . .	47.08	
No. 1 lard oil . . . . .		64.07
Winter-strained lard oil . . . . .		73.97
Prime steam lard (with 20 per cent. cot- tonseed oil) . . . . .	37.40	
Pure prime neatsfoot oil . . . . .		70.53
No. 1 neatsfoot oil . . . . .		67.41

analysis made by the purchaser's chemist. It is always advisable, when time permits, to perform all operations in the various analyses with the greatest accuracy possible, and to apply the rougher and cruder methods only when a quick, approximate result is demanded.

By the rapid methods that will hereafter be described, results are obtained that in no sense will stand against scientific and accurate analyses, yet they serve admirably the purpose for which they are intended. Most of the analyses made in the packing house are made with all possible accuracy, such, for example, as the determination of the Hübl iodine number, the free fatty acids of oils, tallow, etc. For the accurate determinations of the composition of fertilizers, the methods given in *Quantitative Analysis* should be applied.

**68. Scheme for Rapid Analysis of Fertilizer.**—The mode of procedure in the rapid analysis of bones or tankage in the packing-house laboratories for working results is carried out in the following manner:

The sample, if pressed tankage or wet bones, is dried in the usual manner to a degree that will permit it to be ground in a mill. An ordinary coffee mill is well adapted for this purpose. If the percentage of moisture in the bones or the pressed tankage is desired, the sample is made completely dry and the amount of moisture evaporated is calculated in the usual way from the loss in weight (see *Quantitative Analysis*). The sample is put through the mill until sufficiently fine to have an even, uniform, very finely divided mixture. Twenty grams of this mixture is weighed off in a weighed 3-inch porcelain dish and then dried at 102° C. in the drying oven to a constant weight. This generally requires about 3 hours.

While the 20 grams just mentioned is drying, 1 gram of the sample is weighed off in a 4-ounce Erlenmeyer flask, or

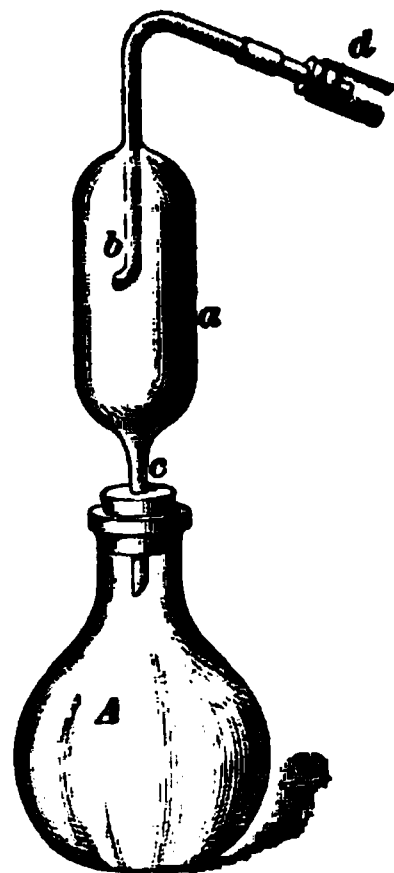


FIG. 9

a Kjeldahl digesting flask, and prepared in the usual way for the nitrogen determination by the Kjeldahl method. (See *Quantitative Analysis*.) For distilling off the ammonia, a distilling bulb, as shown in Fig. 9, is used. The liquid to be distilled is placed in the flask *A*. Into the stopper *c* is inserted the bulb. The vapors from flask *A* are freed from liquid in bulb *a* and pass out through the curved tube *b* to the condenser *d*. The curved tube *b* prevents acid liquid from being carried over mechanically. During the drying and digesting of the sample, a portion (2.5 or 5 grams) is weighed off in a weighed porcelain dish, or crucible, and the organic matter burned away. This residue is mainly calcium phosphate and is calculated as described later.

The sample for drying is weighed for loss of weight, which is noted as the moisture present. This portion, thoroughly dry, is now transferred to a filter-paper thimble that fits inside of an extraction apparatus, and the fat is extracted either with light boiling naphtha of about 87° C. boiling point, or with rhigolene. The extraction is continued for about an hour, when all but traces of grease, and fat are removed by the solvent. The operation is conducted as directed later. The digestion for the nitrogen determination has been completed during this time. The sample is now ready for the required determination of nitrogen by the usual method described in *Quantitative Analysis*.

**69.** There have now been determined moisture, nitrogen, phosphoric acid (or bone phosphate), and fat. By drying pressed tankage or wet bones over night, all these analyses may be made and reported within 5 or 6 hours. If the moisture of dried tankage is 10 per cent. or less, then the material will keep in good condition, when piled or sacked for shipment, without heating or becoming lumpy. If the fat in tankage is less than 10 per cent., the work of cooking and pressing is shown to have been done well and in an economical manner. The amount of nitrogen and phosphoric acid in the tankage or other material determines its grade and, approximately, its market price.

For comparative purposes, tankage is always reduced to a moisture basis of 10 per cent. In this way it is immaterial whether tankage is dried to 1 per cent. or 20 per cent. moisture for comparison with other tankages, when they also are reduced to 10-per-cent. moisture basis; the relative values may easily be seen. To obtain this result, the various percentages of the ingredients are multiplied by 90 and the result divided by the percentage of dry substance. For example, a dried blood analyzes 18 per cent. of ammonia and 2 per cent. of moisture. To obtain this on a basis of 10 per cent. moisture,  $18 \times 90 = 1,620$ , and  $1,620 \div 98 = 16.53$ . Thus, the result may be expressed as blood of 10 per cent. moisture containing 16.5 per cent. of ammonia is the equivalent of blood of 18 per cent. ammonia with 2 per cent. moisture.

**70. Determination of Fat in Bones and Tankage.**—The amount of grease left in the pressed tankage is the guide to the foreman or superintendent for correct, close, and profitable working in the fertilizer department. This analysis, though exceedingly simple, is one of the most important in the daily routine of the packing-house laboratory. The method employed for this determination is as follows:

The sample of bones, bone tankage, or tankage is dried in any convenient manner at a temperature not exceeding  $102^{\circ}$  C. The material is then reduced to a very fine condition and further dried to drive off all moisture. In the extraction of fats, it is very essential that the fertilizer material be dry, or it will not be possible to extract the fat by reason of the moisture forming

FIG. 10

an impervious coating on the material, through which the solvent will not penetrate.

The dried fertilizer is transferred into a filter-paper thimble made for extraction purposes, and the material is pressed down with a wad of absorbent cotton, which serves to keep fine particles from being carried over into the flask containing the solvent. The thimble *c*, Fig. 10, containing the fertilizer, is inserted into the Soxhlet extraction tube *a*, which is connected with the usual condenser *d* and fitted into the weighed flask *b*, which has a capacity of about 100 cubic centimeters. About 75 cubic centimeters of light boiling naphtha of 86° C. boiling point is used; or the extraction may be accomplished with rhigolene. The flask is usually heated by means of hot water or steam, as the danger from fire when heating with direct flame is too great.

The heating is continued until all the grease or fat has been extracted from the fertilizer, which generally requires about an hour. If an exact determination of fat is desired, the heating may be continued for 2 or 3 hours, during which time the solvent will have been siphoned off about 100 times.

**71.** The apparatus is drained of solvent into the flask *b*. The thimble *c* is now removed, the flask again attached to the Soxhlet tube, and the solvent distilled into *a*. As fast as the tube *a* is filled with solvent, it is detached, and the distilled solvent is decanted into a receptacle to be used again for other extractions.

The last traces remaining in the flask with the dissolved fat are driven off by placing the flask and fat in the drying oven and heating until the solvent is completely volatilized, which will not require more than an hour. The increase in weight of the weighed flask multiplied by 100 and divided by 20, the number of grams of material taken, will give the percentage of fat or grease extracted from the fertilizer material.

Ether cannot be used for extracting packing-house tank-ages, as this solvent will dissolve compounds, such as glycogen, etc., contained in the livers, and thus give errone-

ous results. It has been found that light boiling naphthas are the most satisfactory for extracting fat or grease from this class of material.

**72. Rapid Method for the Approximate Determination of Bone Phosphate.**—In packing-house laboratories, the following rapid method is used extensively for determining the approximate amount of bone phosphate in steamed bone, raw bone, bone tankage, etc. This method is not applicable to fertilizers in general, as there are too many inorganic ingredients present; but for packing-house products, being of organic origin, it is readily applicable.

The material is made in the usual manner into an average fine condition. Two and one-half grams of the substance is weighed into a weighed porcelain crucible of ample capacity, and the organic matter is burned away. The heat of the ordinary Bunsen burner is sufficient for this. The material should occasionally be stirred with a platinum wire so as to expose the underlying parts to the air. When cooled in the desiccator, the ignited ash is weighed with the crucible and the weight of the crucible deducted. The ash is mainly tricalcium phosphate,  $Ca_3(PO_4)_2$ , of a molecular weight of 307.9.

By multiplying the weight of the ash by  $.86 \times 100$  and dividing by the weight of the sample taken, the percentage of bone phosphate (tricalcium phosphate) will be obtained, the ash being considered as 86 per cent. bone phosphate. From constant comparative tests, this calculation has been found to be very close to the actual amount present, at least sufficiently so for comparative purposes.

The determination of *actual* phosphoric acid present in fertilizer, bones, etc. is carried out as described in *Quantitative Analysis*. For this analysis,  $2\frac{1}{2}$  grams of tankage, or 1 gram of fine bone, is the quantity taken.

While the preceding method is always applicable to regular packing-house products, it should not be used in practice unless positive assurance is had that no other substances have been mixed with the material.





# MANUFACTURE OF LEATHER

(PART 1)

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## HEAVY, OR FIRM, LEATHERS

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### TANNING MATERIALS

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#### INTRODUCTION

**1. Leather.**—The term **leather** is applied to the product obtained by the treatment of hides or skins of animals with certain reagents that convert the animal tissues into a tough, opaque, pliable, and fibrous substance which is not subject to putrefaction.

The process by which the skins are converted into leather is known as **tanning**. Not the entire substance of the skin is affected by tanning agents, but only that portion known as the *corium*, or inner skin. The structure of the skin will be fully explained later. The action of tanning agents is one of chemical and mechanical combination with the fibers of the corium, so that on drying they do not agglutinate and form a stiff mass.

**2. Tanning Agents.**—Tanning substances may be grouped into three divisions, as follows:

**1. Vegetable Tannins.**—The vegetable tannins are organic substances containing tannic acids and are obtained from barks, nuts, seed pods, and portions of certain trees. The ground material, its infusions, and its dried extracts are also used.

2. *Mineral Salts*.—Tanning by means of mineral salts is known as *tawing*. Alum and sodium chloride are used in some tanning processes, also salts of iron and chromium.

3. *Oils and Fats*.—Various kinds of fish oils and tallow are used in tanning chamois skin and in making so-called oil-tanned leather.

3. For the production of different kinds of leather the tanning industry necessarily includes a number of subtrades, in each of which practice differs widely. All, however, have a common starting point—the raw hide—and this material varies from the delicate lambskin for fine gloves to the heavy ox hide for men's shoes. The process for tanning the lambskin into leather would not do for treatment of an ox hide, and so different divisions of the tanning industry have not all progressed at the same rate; hence, in any consideration of the general subject of tanning, the processes commonly identified with each branch will be taken up separately.

There are some operations that are followed, with more or less variation, in all kinds of tanning, and an explanation of these operations, preceded by a discussion of the materials used, will make later reference more readily understood.

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#### VEGETABLE TANNING MATERIALS

4. As a result of the diligent research that has been going on for many years, the number of vegetable tannins available for tanning has been greatly increased and the cost of tanning materials has been lessened.

Of late years, the economical leaching of bark has served to lengthen the time during which the native barks will be available; the use of wood extracts has also served to protect and increase the life of bark tanning, and as the supply of wood from which these extracts are made is practically unlimited, this generation has nothing to fear from a shortage of tannins.

5. In the tanning of hides for sole leather, the following vegetable tanning materials are most frequently used:

*Hemlock bark* is the most important tanning material used in America, about 60 per cent. of all leather made being tanned by it. It is the bark of *Abies Canadensis*, and in the East it contains about 11 per cent. of tannin. The tannin content of Western hemlock may run as high as 18 per cent. Hides tanned with it make tougher leather than skins tanned with oak bark, but the leather is not so pliable. Both solid and liquid extracts of hemlock bark are on the market.

*Oak bark* is also one of the important tanning materials. It is the inner bark of several varieties of the oak tree, as the English oak (*Quercus Robur*), the rock-chestnut oak (*Quercus monticola*), and the yellow oak (*Quercus tinctoria*). White oak (*Quercus alba*) and the red oak (*Quercus rubra*) are not so valuable, because of their lower tannin content and undesirable color. The tannin of the several varieties of oak is known as quercitannic acid,  $C_{17}H_{16}O_{11}$ . There are four anhydrides of this acid, the first, phlobaphene,  $C_{22}H_{18}O_{11}$ ; the second,  $C_{22}H_{18}O_{10}$ ; the third, Oser's oak red,  $C_{22}H_{18}O_{10}$ ; and the fourth, Löwe's oak red,  $C_{22}H_{18}O_{10}$ . Quercitannic acid and phlobaphene only are of importance in tanning.

*Canaigre* (*Rumex hymenosepalus*) is a native of the arid Southwest. Some recent attempts have been made to cultivate it and introduce it as a tanning material, but with little success. The coloring matters and starch that are extracted from it affect the quality of the leather.

*Quebracho* is the name of several hardwood trees growing in South America. The wood and bark of *Quebracho colorado* contain from 15 to 20 per cent. of a bright-red tannin, but do not contain enough non-tannins to aid the formation of fermentive acids necessary to plumping, nor will it yield a full, well-nourished leather unless combined with other forms of tanning agents richer in non-tannins.

*Palmetto root* is obtained from the palmetto tree found abundantly in the Southern lowlands. This root has been attracting considerable attention for the past few years among the Southern tanneries. The root is cut up and treated like bark. Its action is quick, and the leather tanned by it is tough.

*Gambier* (*pale catechu*) is an important tanning agent. It is the dried extract from the leaves of *Uncaria gambier* and *Uncaria acida*. The extract is readily soluble in warm water. It contains from 36 to 40 per cent. of a brown tannin that rapidly penetrates the hides and tends to swell them; taken alone, it produces a soft, porous tannage. It is largely used with other tanning materials for both light and heavy leathers. It is exported from Singapore in pressed blocks and cubes.

*Catechu*, or *cutch*, is the dried extract from an East Indian tree, *Acacia catechu*. It contains from 45 to 55 per cent. of a special variety of tannic acid. The extract is evaporated until a thick, dark-brown product is obtained, which solidifies on cooling. In this form it is exported.

*Gallnuts*, or *nutgalls*, are excrescences on certain plants, caused by gall flies, which puncture the bark in order to deposit their eggs. Oak gall, or Aleppo galls, and Chinese galls are the most important. The oak gall is formed by the insect on *Quercus infectoria*. The eggs hatch and the larva develops within the gall. The best galls are gathered before the fly becomes fully developed, and contain from 60 to 70 per cent. of gallotannic acid. The Aleppo galls are the most valuable.

*Mangrove bark* has of late years become popular as a cheap tanning agent. The mangrove tree grows in swamps in tropical and semitropical countries, and the bark contains a quantity of tannic acid, varying with the locality of growth. The African bark is the strongest in tannin, running as high as 45 per cent.; South- and Central-American bark contains as much as 28 per cent., while the Florida bark rarely has more than 22 per cent. of tannin. When used alone, the African bark gives a rather harsh leather of a bright-red color, but it makes an admirable combination with native American barks.

*Sumac* in all its varieties is a common and valuable tanning agent. It consists of the powdered leaves of the so-called tanners' sumac (*Rhus coriaria*, *R. typhina*, etc.). The best sumac comes from Sicily, but Italian, Spanish, French, and American sumac is found on the market. Sumac contains

from 15 to 30 per cent. of a light-colored tannin, which is in great demand in the manufacture of some classes of leather.

*Chestnut wood* is largely used for extract manufacture in the United States, but mixed with bark, its use in the tannery leach house is becoming quite common. The wood found in the Northern states contains from 5 to 8 per cent. of tannin, while Southern chestnut wood often contains as high as 11 per cent. of tannin. The chestnut tree, being of quick growth, offers a solution to the problem of offsetting the decrease in vegetable tanning agents.

*Valonia* is the commercial name for the acorn cups of several species of oak (*Quercus ægilops* and *Quercus macrolepis*) coming from Asia Minor and Greece. They contain from 25 to 35 per cent. of tannin, somewhat resembling that of oak bark, but giving a browner color and heavier "bloom." It makes a hard, water-resisting leather and is sometimes mixed with oak bark for use in sole-leather tanning.

*Divi divi* is the dried seed pods of a South American bush. The pods are about 3 inches long, of a brownish color, and bend in the form of the letter S in drying. These pods contain from 30 to 50 per cent. of a peculiar tannin somewhat similar to that of valonia.

*Myrobalans* are the dried fruit of several species of *Terminalia* from Hindustan, Ceylon, etc. They contain from 28 to 35 per cent. of tannin, and are generally used in combination with other tanning agents. Some varieties cause a "bloom" similar to that of oak bark, and all varieties are great acid formers in the tan yard.

*Mallet bark* is an Australian product containing as high as 50 per cent. of tannin similar to oak bark in color.

**6. Classification of Tannins.**—The tannins in tanning materials are different members of a large group of organic bodies known chemically as *tannic acids*, or *tannins*. They differ widely in chemical constitution and reaction, but all have the common property of precipitating gelatine and forming insoluble compounds with animal tissue. They are

all compounds of carbon, hydrogen, and oxygen, but their ultimate structure is little understood.

When heated, the natural tannins yield catechol,  $C_6H_4(OH)_2$ , or pyrogallol,  $C_6H_3(OH)_3$ , and sometimes both. The classification of tannins on these chemical lines bears out an old classification made on the appearance of the tannage.

7. Tannins were formerly divided into those which yield the whitish deposit on the surface of the leather, called *bloom*, and those which do not. Most tannins that give a bloom to the leather are *pyrogallol tannins*; a solution of their non-tannins when separated has an opalescent appearance. The tannins that give no bloom to leather are classed as *catechol tannins*.

When treated with sulphuric acid, the pyrogallol tannins yield gallic acid or ellagic acid, the latter combining with tannic acid to form the bloom. Under this treatment, the catechol tannins yield the reddish-brown insoluble bodies known to all tanners as *reds*. These reddish-brown insoluble bodies differ from the original tannins in containing fewer molecules of water, and are therefore anhydrides of their especial tannic acids.

Hemlock bark yields a series of these reds; the higher members are soluble, precipitate gelatine, and are the principal coloring materials of the bark. The lower members are insoluble at ordinary temperatures and form the sediments found in the tannery vats.

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#### WOOD AND BARK EXTRACTS

8. The use of bark and wood extracts in the process of tanning is becoming more general every year. There are few tanneries where extract is the exclusive tanning agent and but few tanneries where it is not used to some extent. Primarily, an extract is valuable because of the annual decrease of tan bark that its use has brought about. It brings the strength of distant virgin forests to the aid of our own failing supply of bark. As a convenient means of

quickly strengthening a weak liquor, without the addition of the same amount of insolubles that would be added were the ordinary bark liquor used, it is decidedly useful. The extracts made from some barks and woods are valuable for the color that they impart to inferior tannages on which they may be used.

In sole-leather manufacture, extracts are generally used for strengthening the liquors and occasionally to improve the color of the stock. In some branches of the upper-leather industry, the pelts are partly tanned in bark liquors and then finished in liquors made up entirely from extracts, thereby imparting the distinctive characteristics of the tannin of the bark or wood from which the extract was made.

In the shortened method of modern sole-leather tanning, the undiluted liquid extract is "drummed" into the tanned hides, thereby saving time and increasing the weight of the leather.

**9. Manufacture of Extracts.**—The manufacture of extracts is carried on to a large extent in the United States, South America, Europe, and Asia. Wherever there is a sufficient supply of the tanning material, handicapped by prohibitive freight rates, the extract works solve the commercial problem of economical distribution.

The material to be extracted is ground fine and the leaching takes place in the same manner as at the tannery; details as to the duration of the leaching, temperatures, etc. being determined by the particular substance undergoing extraction. The liquor is then treated by some sort of clarification process, either mechanical or chemical, or both, to remove fine, insoluble materials.

Numerous methods of clarification are in use among extract manufacturers. Use is made of dried blood and other albuminous products that, in coagulating, envelop the solid particles and settle out. Inorganic processes, such as the use of acetate of lead, or the precipitation of barium sulphate directly in the tank, have been devised, but these processes remove more or less tannin, in addition to the



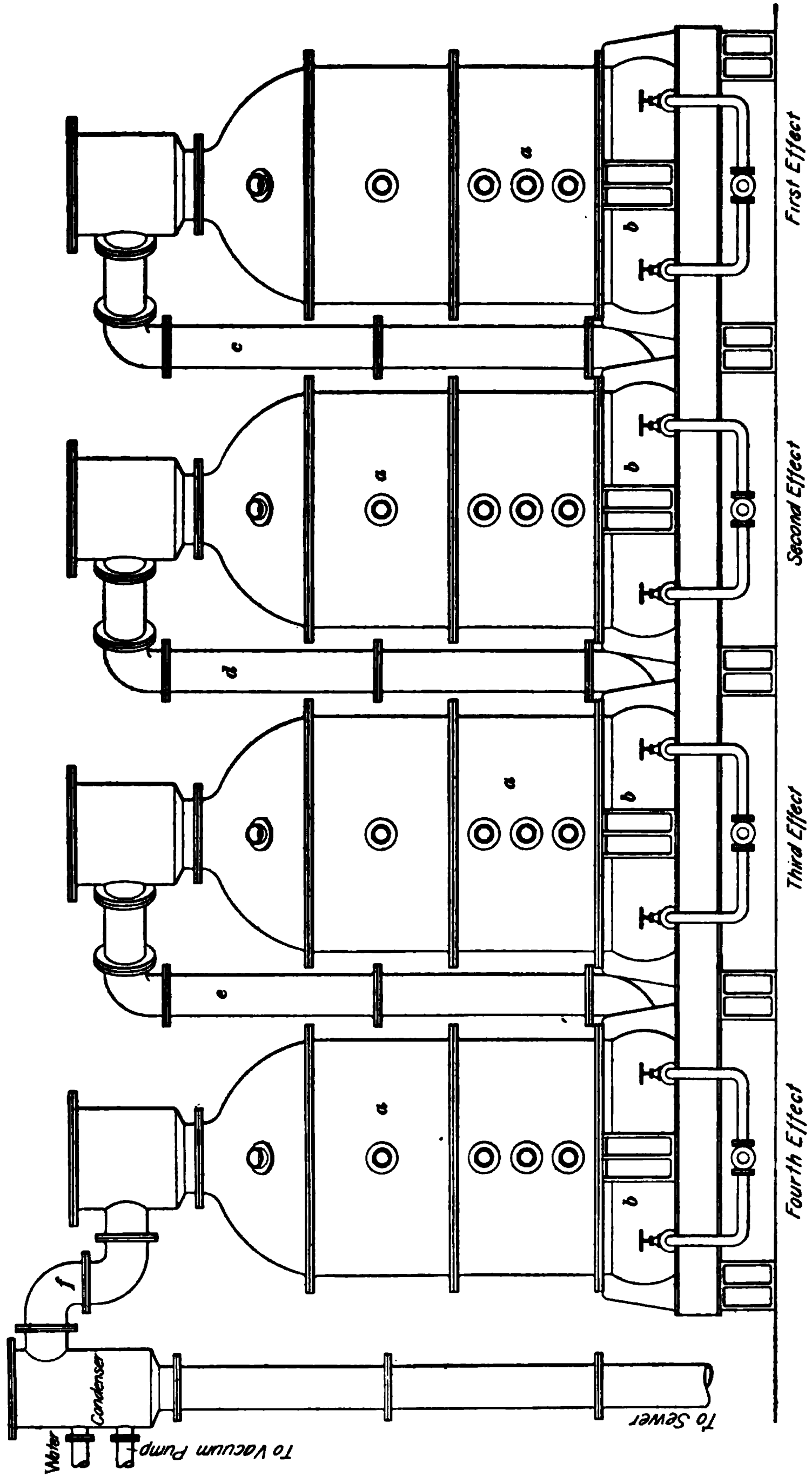


FIG. 1

insolubles taken out. Purely mechanical processes of clarification consist in the settling of the liquor in vast settling tanks or by slow filtration through some coarse fabric.

The older methods of clarification depended on the removal of the insoluble particles, or reds, to accomplish the clearing of the liquors; the later clarifying processes aim to make these reds soluble, thus making a clear extract, and at the same time render the reds available as tannins. For this purpose, sulphurous acid, alkalies, or bisulphite of soda are used. When these chemicals are used, the clarification of the extract should not take place until the concentration of the liquor has been nearly accomplished. The use of alum, or salts of aluminum and chromium, is also frequently resorted to, in order to remove the objectionable red color of some extracts, like that made from hemlock bark and from some varieties of quebracho wood.

10. The liquors from the leach house are concentrated in vacuum apparatus, multiple-effect vacuum pans generally being used because of the resulting economy in the cost of operation. A standard quadruple-effect pan is shown in Fig. 1. Each "effect" is exactly like the others and consists of a cylindrical copper body *a* bolted to a steam drum *b*. The steam drum in a standard vacuum pan consists of a circular drum of copper having a great number of vertical copper tubes, the upper and lower ends of which are expanded into openings in the upper and lower heads of the drum. The steam drum has a circular well in the center, generally of a diameter equal to one-third the diameter of the drum, to help the circulation of the liquors while boiling. Vapor pipes lead from the top of the body of one effect to the steam drum of the next, the vapor pipe from the last effect being connected with the condenser. Pipes for conveying the thin liquor to each pan, and for conveying the liquor from one pan to the other, are provided, as well as pipes for conducting the condensed steam and vapors from the steam drums and for removing the finished extract from the last effect.

Liquor is put in the pan, condensation water removed from the steam drums, the finished extract removed from the last effect, and the vacuum maintained by different pumps adapted to the work.

11. In operation, the pans are charged with liquor, pumps are started, and steam turned into the steam drum *b* of the first effect; the steam surrounding the multitude of tubes in the steam drum is rapidly condensed, and the liquor in the pan soon begins to boil. The vapor from the boiling liquor passes through the vapor pipe *c* into the steam drum *b* of the second effect, gives up its heat to the liquor in this effect, and is condensed. The vapor from the liquor in the second effect goes through the vapor pipe *d* to the steam drum *b* of the third effect, and the vapor from this effect goes through the vapor pipe *e* to the steam drum *b* of the fourth effect. The vapor from the fourth effect goes through the pipe *f* to the condenser, where it is condensed by a spray of cold water. The condenser is attached to a leg pipe about 35 feet long, having its lower end sealed in a water well overflowing to the sewer; the suction pipe of a vacuum pump is attached to the lower part of the condenser and maintains a vacuum of from 24 to 27 inches of mercury in the condenser and last effect. This lowers the boiling point to such an extent that liquor boils in the last effect at a temperature close to 150° F. Vapor coming from the third effect is quickly condensed in the drum of the fourth effect and causes a decrease in pressure in the body of the third effect. The boiling point in the third effect is thus lowered, causing a slight vacuum that influences the pressure and boiling point in the second effect, and in turn the condensation of vapors coming into its steam drum is thereby quickened.

The vacuum on the first, second, and third effects is materially increased by the suction of the pump used to remove the condensation from the drums. In practice, it is customary to maintain a steam pressure of 5 pounds on the drum of the first effect, a very slight vacuum in the first

effect, and a regular increase in vacuum thereafter, until the maximum is reached in the last effect. The liquor is pumped into the first effect, from which it is sucked to the second, and from the second to the third, and from the third to the fourth, the liquor in all effects being maintained at the desired level by regulating the valves on the pipes connecting the pans, so that enough is admitted to replace the amount evaporated. When the desired concentration is reached, the extract is slowly pumped from the last effect to the clarifying tank, or to the storage tank in case the liquor is not to be clarified.

12. Some extracts are marketed with a specific gravity of 1.22, or 44° Twaddell, others are still further reduced to a specific gravity of 1.26, or 52° Twaddell, while practically all the foreign extracts come to the United States in the solid form, containing from 20 to 25 per cent. water.

*Hemlock-bark extract* has been longest on the market. It is made from the common hemlock bark in localities where hemlock grows plentifully and shipped to other points not so favored.

*Rock-oak bark, chestnut-oak bark and wood, mangrove, sumac, quercitron, mimosa, quebracho, gambier, acacia,* and other woods and barks are extracted, and their extracts form valuable adjuncts to the ordinary tan liquor.

Among American tanners, the standard extracts are *quebracho* and *chestnut wood*.

*Quebracho extract* is made from the wood of the *quebracho* tree, a close-fibered wood that grows in South America. It produces a fine-colored tannage, but is better adapted to the tanning of upper leather than for sole leather, as its low non-tannin content tends to keep it "sweet"; that is, it does not foster the growth of organic acids necessary to plumping.

*Chestnut-wood extract* is made from the wood and bark of the chestnut tree, found in nearly all parts of the United States. Used in connection with other tanning materials, it is perhaps the most valuable of extracts, because of the practically unlimited supply of raw material. The tree grows

quickly, and if the young trees on a stripped tract are forested, the original growth will be duplicated with trees large enough to cut in from 15 to 20 years.

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#### PREPARATION AND LEACHING OF BARK

**13.** The leaching of bark is an operation in tanning by which thousands of dollars have been allowed to go to waste through improper manipulation. Even at this late day, tanners are leaving in the cast-off bark as high as 25 per cent. of its original tannin content. When the theory of leaching is understood, there should be no excuse for this wanton waste.

The principles of saturation and equalization underlie the theory of leaching; a piece of hot iron placed in water loses its heat to the water and becomes colder, while the water is warmed by the iron until finally both iron and water are of the same temperature. The same principle is involved in the process of leaching; both the leach and liquor become of equal strength. A strong liquor run on a spent leach will come off the leach weaker than when it ran on. In a perfect leaching system, the object is always to run a liquor on a leach that can add tannin to the liquor.

**14. Preparation of Bark for Leaching.**—Various methods of preparing the bark for leaching are in use. They all consist of some kind of grinding and shredding. Proper preparation of the bark is important and quite essential to close leaching; the best leaching system will not produce good results unless the bark is reduced to such a state that the water or liquor can readily penetrate to every fiber.

Mills for grinding bark have the common feature of a revolving disk into which cutting knives are set radially. Most of them have a secondary disk that completes the work the first disk started; the bark then passes through small apertures to a conveyer.

**15. Ott Bark Mill.**—The Ott mill, shown in Fig. 2, is the most popular of the grinders. It consists of a hopper *a*,

leading to the lower part of the mill, where the grinding is done. A shaft *b*, by means of which the mill is driven, runs through the center of the entire mill, which may be driven by it from either the top or the bottom. The portion of the

FIG. 2

shaft running through the hopper has keyed to it four projecting iron arms *c*, which, with the aid of similar projections *c*, from the inner sides of the hopper, break the bark into small pieces that fall into the runner, or carrier, shown in Fig. 3 (*a*).

The runner, or carrier, consists of a circular piece of steel *d* fitting the lower part of the mill; it is attached to and revolves with the shaft that passes through its center. Attached to the shaft above this disk are four angular iron wings *e* that extend to the edges of the disk and are attached to it by bolts engaging the flanges of the wings. The ends of the wings are supplied with steel tips *e'* that form a cutting surface. The knives *f*, Fig. 2, are set vertically and bolted to a slotted cylinder of the same height as the runner, and surrounding it. The bark, having been broken by the upper

(a)

FIG. 2

arms, falls into the runner and is ground by being carried against the knives by the steel-tipped wings. Passing through the knife slots, the bark falls into the bottom of the grinder and is delivered by means of a spout *g* to the carrier *h*, which takes it to the leach house.

The cylinder, shown in Fig. 3 (*b*), containing the knives *f*, is made in segments that can be removed for the grinding and setting of the knives, five of which are held in each segment. The mill is run at a speed of 100 to 150 revolutions per minute; the knives require grinding and setting at

intervals depending on the character of the material that is being ground.

Many tanners prefer a shaving machine that reduces the bark to shreds instead of grinding it. With oak bark it gives better results than the ordinary grinder.

**16. Williams Patent Bark Shredder.**—The machine shown in Fig. 4 is the best known form of the shaving, or shredding, type of machine. It is cylindrical in shape, the casing *a* surrounding a horizontal shaft to which a hub *b* is keyed. Heavy, sharp-pointed arms, or hammers, *c* that pre-

FIG. 4

sent a cutting edge, are hinged to the hub by pinions, and when the shaft is in motion the centrifugal force causes them to radiate from the hub. The hopper *d* is at the side, the floor of the hopper being inclined by a raised plate, the end of which forms a sharp breaking corner so that the bark is cut in small pieces before the final shredding takes place. A segment of a cylinder, shown at the left in Fig. 4, contains the knives *e* and is so placed beneath the revolving arms that the edges of the knives and the sharp ends of the revolving arms form shears and cut or shred the bark forced between them. The shredded bark then falls between the



knives into the conveyers. The segment, or "cage," containing the knives is in the form of a semicircle, and the knives are so arranged that the lip, or projecting edge, presents a shaving, or shredding, surface instead of a pulverizing surface. The knives can be taken from the cage, resharpened, and replaced. A bowed steel shell *f*, with one edge riveted to the top of the casing and the other edge projecting through the hopper opening into the cylinder, forms a chamber for the settling of the dust after it has been moistened by a spray of steam introduced at the side of the hopper at *g*. Economy of power with greater grinding capacity is claimed for this type of machine; it is especially valuable for wood and barks of a fibrous nature.

When ground, the bark is conveyed to the leach house by some form of mechanical conveyer or blower, the former being the cheaper method of conveyance.

**17. Vat Leaching.**—Most of the older leach houses were constructed by sinking the vats in the ground. While this method seems to economize the heat used in latter-day leaching, inability to repair leaks is a serious objection to them, and all the newer types of leach houses are constructed with the bottoms of the vats above ground. In this way, leakage is detected and stopped, and the spent, or exhausted, tan is much more easily removed from the leaching vats. Mechanical contrivances for handling the bark before and after leaching are in general use. The vats, or "leaches," are filled from an overhead conveyer leading from the bark storehouse; and when the bark has been leached, the spent tan falls through an opening in the bottom of the vat into a conveyer that takes it to the furnace, where it is used as fuel.

The vats used for leaching are usually arranged and worked in sets; the vat containing the freshest bark is known as the *head-leach* and that containing the nearly spent bark is called the *tail-leach*.

The vats, or leaches, arranged in sets or sections are provided with perforated false bottoms, and they are so piped

that the liquor from the bottom of one leach is delivered to a box on the top of the next leach in the section and falls either directly on the bark or is distributed over its surface by means of an arrangement known as the *sprinkler*. The sprinkler is made of two pieces of brass pipe screwed into a tee, which, by means of a swivel joint, is connected with the pipe leading down from the box on top of the leach. Each arm of the sprinkler has a row of perforations, and the ends of the arms are closed by removable caps to admit of cleaning. The perforations on one arm are opposite those on the other, so that when liquor flows through the box into the sprinkler one arm delivers liquor in one direction, and the other arm delivers it in the opposite direction. This causes the sprinkler to revolve and spread the liquor over all parts of the bark.

18. The general scheme for leaching with vats is to run water on the tail-leach, and after the liquor comes off it is put on the next, and so on throughout the set until the liquor comes off the head-leach, when it is sent to the settling tanks or storehouse. The tail-leach, after receiving all the water intended for it, is emptied or "pitched," filled with fresh bark, and becomes the head-leach, the leach next above it becoming in turn the tail-leach.

This method of handling the liquors is common to all systems of vat leaching. It is in the method of applying the water, of removing the liquor from leach to leach, the temperature of the liquors, the depth of the vats, and in many other minor details that the various systems differ.

With some systems, the use of warm liquors on every leach is advocated, the water going on the tail-leach being as near the boiling point as possible; the water becomes cooler as it goes to the next leach and finally becomes too cool, in the judgment of the advocates of this system, and is reheated.

Some leaches have steam coils, protected from the bark by a false bottom, in order to maintain the temperature deemed necessary for proper leaching. Other leaches have in the box on the top of the leach a coil of steam pipe for

heating the liquor from the preceding leach. Hot leaching, if not carried to extremes, is the most economical method. When the continued use of very hot waters is resorted to, the reds and the resinous matters of the bark are dissolved in the liquor. These reds are of no use in tanning operations, and serve to make an impure liquor, their proportion to the amount of tannin that is removed by the extra heat being altogether too large to be economical.

Within certain limits, the higher a column of bark through which a liquor passes, the stronger is the liquor and the more perfect the leaching; the weight of the column is limited by its interference with the circulation of the liquor. When the leach is too deep, the bark packs down tightly and stops the even percolation of the liquor.

**19.** In some systems of leaching, the liquors are moved from leach to leach by pumps worked by a common rod. The conditions, however, are not the same in each leach, and hence pumping devices should be fitted to each leach separately, so that the regulation of their speed may be under control.

The "air" system of handling leach-house liquors is now quite common, and it is probably the best method of moving these liquors. Compressed air is admitted to the bottom of the upright pipe that conveys the liquor from the bottom of one leach to the top of the next, and raises the column of liquor in the pipe until it flows into the liquor box on the top of the next leach.

It is the practice in some tanneries to empty a leach of liquor entirely and then run on more liquor. The leaches should be kept covered with liquor at all times. If one is drained free from liquor, the bark settles down and packs tightly; the liquor running on the bark when in this state channels its way to the bottom and uniform percolation is not secured.

A constant and slow influx of liquor on the leach is preferable to a large stream. The liquor should be given a long contact with the bark. It should be delivered on the top of the leach in a divided stream and not in a single strong jet.

Partly spent liquors are frequently returned to the leach house in order to be strengthened and also to keep up the general strength of the leach-house liquors. The returned liquors are generally run on the upper leaches of the section, as the lower leaches, being nearly spent, would take strength from instead of adding strength to the liquor. While the partly spent liquors have lost a considerable part of their tannin during the tanning operations, they still retain a large proportion of their original non-tannin content; when strengthened, therefore, they do not represent the tannin strength that is possessed by a new liquor of the same specific gravity.

20. A complete description of a leaching system will give a general idea as to the mode of operating. The leaches are circular in form, 12 feet in diameter, and 15 feet deep, with plank covers, and with heater boxes on top of them. The liquors are moved by means of the air system. Water as near a temperature of 212° F. as possible is run on the tail-leach, from the bottom of which it is pumped to the heater box of the next leach. Here, it is reheated while passing over the steam coils and falls through a pipe into the leach. The liquor passes through each leach successively and is reheated until it reaches the leach next to the head-leach. Here, it is not reheated, but passes through the bark and comes into the box on the head-leach at about 150° F. The sprinkler used on the head-leach distributes the liquor over the surface of the bark. When the head-leach is "wet down" or filled with liquor, the liquor is run off to the "cooler" or storage vats. The pumping from this head-leach is continued until the liquor becomes too weak for use in the tannery. When used yard liquors are returned to the leach house, they are pumped into the heater box on the top of the head-leach, heated, and distributed over the bark by the sprinkler. After all the returned liquor has gone into the heater box, the liquor from the leach next to the head is pumped into the head-leach and the regular leach-house process continues.



The bark in the leaches is kept covered with water or liquor at all times, and the pumping from one leach to the next is regulated with this end in view.

The preceding remarks on leaching apply particularly to the leaching of such common barks as hemlock and oak, but with other materials the general principles are the same, and, except for variations in the size of leaches and in the temperature of operation, the method of procedure is similar.

**21. Drum Leaching.**—For some materials rich in tannin, autoclaves, or metallic cylinders, in which the leaching is carried on at different pressures, are used. Drum-leaching systems have been used on oak and hemlock barks, but for these materials they are not necessary; drum systems have been very successfully used in the leaching of some high-priced imported barks and woods containing high percentages of tannin.

The apparatus of the Vaughn drum system is shown in Fig. 5. The drums *d*, situated at the floor level, are driven by the belt *a*. The dry tan bark is delivered to the drums by the conveyer *c* and the spouts *b*. The conveyer *e* is for removing the spent tan. The pumps *f* are for handling the liquor; *g* is the ground line. In this system, the bark is placed in the drums and the water run in, the drum doors closed, and the drums revolved, thus bringing the water in constant contact with every particle of bark and also agitating the contents so that a liquor of uniform density is always present in the drum. The laws of saturation and equalization must always be observed, and after the liquor has reached a certain point of saturation it must be changed and run on stronger bark, weaker liquor taking its place in the first drum. Closer leaching in shorter time can be effected in this manner than in any other.

**22. Density, or Specific Gravity, of Tan Liquors.** The density of tan liquors is determined by means of a form of hydrometer called a **barkometer** and having a graduated scale showing "degrees barkometer," or, as it is generally written, degrees "Bark." One degree Bark. repre-

sents the density of a liquor having a specific gravity of 1.001, barkometer degrees being the decimal portion of the specific gravity figure read in thousandths; thus, 10° Bark. is specific gravity 1.010, 45° Bark. is specific gravity 1.045, etc.

A barkometer merely shows the density of a liquor, or its weight compared to that of water; it cannot determine the tannin strength of a liquor, as one 20° Bark. tan liquor might contain 3 per cent. of tannin and another liquor of the same density might contain only 1.5 per cent. of tannin. Non-tannins and other soluble constituents of tan liquors influence the density, and hence the mistake should not be made of considering a 25° Bark. liquor necessarily stronger in tannin than a 20° Bark. liquor. The barkometer readings should be made with the liquor at a temperature of 60° F., or else a correction should be made to compensate for the expansion or contraction of the liquor. If warmer than 60°, the liquor will show less barkometer strength; if colder, it will show more, so that all readings should be made at, or corrected to, 60° F.

The specific gravity of an extract is generally denoted in degrees Twaddell. One degree Twaddell is equivalent to a specific gravity of 1.005, being one-fifth of the decimal portion of the specific-gravity figure when the latter is represented in thousandths. Thus, specific gravity 1.225 is 45° Twaddell, specific gravity 1.400 is 80° Twaddell, etc. From this relation, it is evident that 5° Bark. is equal to 1° Twaddell, or 45° Twaddell is 225° Bark.

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## PRINCIPLES OF HEAVY-LEATHER TANNING

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### STRUCTURE OF ANIMAL SKIN

**23.** In structure, all animal skin is made up of several readily defined layers. The skin is not merely a covering for the animal, but also serves as a container for nerves and secretive glands, and as a bed, or ground, for the hair, or fur. It is made up of two principal layers: the *epidermis*, or *cuticle*,

and the *corium*, or *true skin*. These two layers are totally distinct in structure, origin, and functions, and under them lies the under skin.

**24.** The **epidermis** is a thin covering of the true skin and is entirely removed before the tanning operations begin. In life, the upper, or external, part is being constantly worn away, falling off in the form of dry scales. The interior part of the epidermis is made up of numerous living nucleated cells; as the surface of this layer is reached, these cells become flattened and finally dry up to form the exterior part of the epidermis and ultimately drop off as dead scales. These cells, which renew the horny external tissue of the epidermis, are in turn renewed by vessels situated in the corium, or true skin. The epidermis does not combine with tannin and is removed, laying bare the true skin, which is known to the tanner as the *grain*.

**25.** The **corium**, or **true skin**, is the skin with which the tanning agents combine to form leather. There is an intermediate layer of the corium next the epidermis. Both layers are composed of interlaced bundles of fiber running across and above one another and parallel to the surface of the skin. They contain and are surrounded by fluid matter, which serves to keep the skin in a moist and pliable condition. Soaking in water removes this fluid and the fibers alone remain. These are saturated with the soaking water, and if dried by a gentle heat assume a horny appearance and become in substance about one-third of the raw hide.

The corium determines the quality of the leather that can be made from a hide. Its thickness, flexibility, and strength are reproduced in the leather. Between the fibers of the corium is an albuminous substance called **coriin**: in a dry state this holds and connects the fibers.

The connective tissue of the corium gives the form to the skin, the intercellular substance, coriin, lying between the fibers. When boiled with water, these connective tissue fibers form glue, losing their organized structure, and making a homogeneous jelly.



The intercellular substance is probably a decomposition product of the connective tissue. This coriin is soluble in lime water and in baryta water; frequent treatment of the skin with these reagents withdraws fresh quantities of soluble matter with every treatment. This fact should be noted in connection with the liming of skins to remove the hair.

Dilute inorganic acids swell the connective tissue, while strong mineral acids dissolve it. The swelling of the skin by acids is made use of to facilitate tanning; it not only makes the skin more sensitive for the reception of the tanning material, but also effects the disintegration of the fiber bundles into individual fibers, thereby increasing the surface.

**26.** The under skin is made up of loose connective tissue, embedded in which are the sweat and fat glands, the blood vessels, and muscular fiber. The under skin is removed

in the beam-house work and plays no part in the tanning process; the side of the hide on which this connective tissue of the lower skin is located is known to the tanner as the *flesh side*.

Fig. 6 shows an enlarged microscopic transverse section of the skin in which the Malpighian net, or lower layer of the epidermis, is shown at *d*; the corium, at *b*; the lobules of adipose

FIG. 6

tissue, at *m*; the external orifices of the sweat glands, at *a'*; a hair follicle, at *y*; a shaft of hair in the hair follicle, at *x*; a hair papilla, at *i*. At *l* is illustrated the connective tissue

of the under skin, showing the sweat glands *a*, with the ducts *c*, through which the sweat passes to the surface of the skin; at *k* is shown a hair bulb, and at *e* are shown openings of the sebaceous glands. The horny outside layer of the epidermis *h* shows hair, as at *f*, or wool at different places. The hair is not embedded immediately in the surface, but in the capsules, or sacs, being continuous with the epidermis and reaching down to the corium.

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#### TREATMENT OF HIDES

**27.** As before noted, there are some operations in the manufacture of leather that are followed, with more or less variation, in all branches of the industry, and to save repetition these will be treated generally, variations being noted in descriptions of the tanning processes necessary for the production of specific kinds of leathers. These variations are so numerous that it will be impossible to enumerate them all, but enough will be noted to indicate what latitude exists in the application of the general principles involved.

**28. Soaking.**—Whatever may be the class of hide in use at the tannery, the first operation is that of **soaking**. This is always done by means of water, with or without the addition of chemicals. The various kinds of hides require different treatment as to mechanical handling, character of the soak, and the duration of the soaking. Whether the hide is “green” or has been dried with preservatives (in this case these preserving agents must be washed out), the dirt, blood, and dung must be removed, and the hide brought back to a state similar to that in which it was when taken from the carcass. All the foreign matter goes into the soaks, and only a short time elapses before the water becomes filthy.

Where hard water is used, it is customary to add some softening agent, as borax, since soft water is better adapted to soaking purposes. Much valuable hide substance is lost in many tanneries through the use of soaks that have become putrid. An old soak gives better results than a new

one, but if the vat is allowed to become putrid, depletion of the hide takes place, and the loss from this cause more than offsets the time gained. Plenty of pure water with a little borax or soda, if needed, is a much more effectual cleanser and softener than a putrid liquor.

**29.** The general form of receptacle for the soaking is a pit or vat sunk in the ground. Wheels or drums have been used, and in some places are still employed, but the ordinary vat is the most convenient for the purpose. The hides are either hung in the water on racks or thrown in and spread out. Dried hides are generally placed in piles and the water then run on them.

While in the soaks the hides must be watched by skilled workmen so that they will not become putrid. Thin hides must be removed as soon as they become soft, without waiting for the thicker ones to soften. The thin parts of all hides must be carefully watched, in order that they will not become damaged while the heavier parts are softening.

**30. Hide Mills.**—Where heavy hides are being made into sole leather it is customary to use **hide mills**. A hide mill is merely a heavy iron shoe on the end of a vertical beam keyed at the other end. A to-and-fro motion is imparted to the beam by a heavy shaft and the shoe moves in a heavy receptacle containing the hides. The hides are constantly in motion and in contact in running water, and a couple of hours of this treatment is more beneficial than a day's quiet soaking. The hides are first put in the soaks until they become softened, and the mills are then used to finish the operation. Similar, but lighter, mechanical contrivances are used for the same purpose where lighter pelts are treated.

**31. Depilation.**—The **unhairing**, or **depilation**, of hides is commonly accomplished by placing them in a solution of lime until the hair bulb is loosened, thereby allowing the hair to be readily scraped off. The lime acts on the roots of the hair and the hair sheaths are dissolved, but the hair itself is but slightly altered. The lime also acts on

the skin; the fibers swell and absorb water, so that the skins become plump and swollen, and at the same time the substance that glues the fibers together is dissolved and the skin becomes a mass of finer fibers. The lime also saponifies the natural fat, or oil, of the skin.

The use of lime, however, is unsatisfactory and more or less wasteful, owing to its energetic action on animal tissues. More or less of the gelatinous tissue that would form leather is lost, and unless the lime is removed from the hide after it has done its work, the leather will be hard and brittle and will be difficult to tan. The brittleness may also be caused by the saponification of the fats and oil originally in the skin.

**32. Lime vats** are made of timber or of masonry and are sunk into the ground so that the tops of the vats are on a level with the floor. The contents of the vats are made up by slaking the desired amount of quicklime and thoroughly plunging the vats. Generally, two or more lime vats of different ages are used, the hides remaining in one vat for a time and then being moved by hand reels between the vats to the next lime vat.

The time required for liming depends on the kind and condition of skins, conditions of the atmosphere, and the temperature of the limes in use.

The question of when to throw away the limes is also an open one. Some tanners use them until they are almost saturated with decomposing matter extracted from previous hides. A lime in this state becomes a depilator by means of putrefaction and not because of its caustic action.

**33. Lime water** has been proposed as a substitute for the milk of lime in use. It is milder in its action, but also less permanent and requires frequent renewals in order to insure the perfect cleansing of the hides. Lime must be present in the vats, so that a saturated solution of the hydrate of calcium is always surrounding the hides. Some claim that the presence of solid lime is essential; this claim is difficult to disprove because of the slight solubility of the hydrate, and because the lime in solution is rapidly con-

sumed in the depilation of the hide. Much of the residue of the lime vats, generally mistaken for unused lime, is in reality calcium carbonate formed during the liming process. However, it is found practical to have an excess of lime in the vats so that frequent plungings will keep the lime liquor saturated.

**34. Sulphide of soda** is sometimes used with the lime. It forms caustic soda and calcium sulphide when it comes in contact with the lime. The calcium sulphide acts as a solvent for the hair itself and renders easier the removal of the very fine hair. The use of sodium sulphide shortens the unhairing process and causes less loss of hide substance as compared with lime, but it has the disadvantage of causing brittle, harsh leather unless carefully used in comparatively small amounts. Because of its cost, sulphide of soda has not obtained a very wide use in sole-leather tanneries.

All the metallic sulphides are depilatories; the arsenic and sodium salts find frequent use in unhairing fine hides, from which limp leathers are made. In a general way, the process of unhairing these light hides is carried out in a manner similar to the depilation of heavy leather, but the time required is not so long; besides, the time is shortened by the presence of the sulphides. In some cases, the depilatory is spread over the hair side of the skins and allowed to do its work in this manner. Other modifications of the method of unhairing will be treated in the descriptions of the special tanning processes under which they occur.

**35. Sweating.**—In removing the hair by what is known as the sweat process, the hair is loosened by putrefaction of the hair sacs. In the United States, the *cold-sweat system* is generally used, while the *warm-sweat system* is employed abroad. Dry flint hides from Eastern countries are generally prepared by sweating; they must first be thoroughly soaked and all parts softened. For this purpose, the heavy hide mills are valuable adjuncts to the soak pits. Experienced men are employed to watch the hides carefully while sweating, as no hard-and-fast rules can govern their handling.

**36. Cold-Sweat System.**—As used in the United States, the cold-sweat system is carried out as follows: The sweat pits are vaults built of stone, with the proper apertures for ventilation, in order to regulate the temperature. Tight doors are provided, and these may also be used for ventilating purposes. After the hides are thoroughly soaked and softened, they are hung over poles or suspended by the edges in the sweat pit. The doors are closed until the putrefaction begins, and when this takes place careful watching is necessary. The hides are carefully scrutinized, and those in which the putrefaction is far advanced must be removed at once. The presence of a hide in the sweat pit for even a few hours after it is ready to come out may spoil it.

The sweating process hastens the expansion of the hide, opens the pores, and brings the hide back to a state analogous to that in which it was at the time of slaughter; it gives to the dry, wild hide a much-needed development. During the putrefaction process much ammonia is generated as a result of decomposition. Efforts are being made to isolate the specific germ causing the putrefaction that loosens the hair. If these efforts are crowned with success and an antiseptic is found that will be fatal to other germs than those which cause putrefaction, the sweating process will be greatly simplified.

After sweating, the hides are thrown into water or a weak lime bath, which stops further putrefaction.

**37. Warm-Sweat System.**—As practiced in Germany, the warm-sweat system consists in placing the folded hides in an air-tight buried box, which is then covered with spent tan. Steam is frequently used to accelerate the sweating process, but its use is attended with great risk; the heat spontaneously generated by the hides is preferable. This system requires even more care than the cold-sweat process, because putrefaction promoted by heat makes rapid progress and may cause great loss.

If fresh-slaughtered hides are to be depilated by the sweating process, the flesh side is thoroughly salted and the

hides then folded; they are piled one on another and covered with straw. They are taken down after 18 or 20 hours, the hides opened and refolded, and again piled and covered, after which only occasional turning is needed until the hair begins to slip. In the United States, most of the fresh-salted hides are limed and not sweated.

**38. Unhairing and Fleshing.**—After the liming or sweating operation is completed, the hides are ready to have the loosened hair scraped off and to have the fleshy and fatty matter on the flesh side removed. These operations are known, respectively, as *unhairing* and *fleshing*.

The unhairing and fleshing of hides is done both by hand and by machine. The latter method is slowly superseding the hand method, being retarded because of the care needed in operating the machine. An unskilful or careless operator may spoil hundreds of dollars' worth of hides in a day's work, and the greatest care and judgment must be exercised on the part of the workman while running the machine.

The operations of unhairing and fleshing take place in what is known as the *beam house*. After the hair on the hides has been loosened, they are brought into the beam house; if the sweat pit has been used to loosen the hair, the hides are placed in cold water, which cools them and interrupts the putrefaction that has set in. Limed stock is generally unhaired without previous washing, being brought directly from the limes to the beam house.

**39.** The beams on which the hand process of **unhairing** takes place are convex slabs of stone, one end resting on the ground while the other is about the height of the workman's waist. Over these sloping stones the hides are spread and by means of a concave knife, the curvature of which conforms to that of the beam, the hair is removed. The operation is fatiguing, and only men of long experience, skill, and considerable strength are employed.

The knife is pushed against the hair, the sides being worked from the hind shank toward the head and then toward the back. Occasionally, very fine sand is used to

facilitate the removal of the hair from places where it sticks. In removing the short, fine hair, hides are occasionally damaged by having the grain cut; to prevent this, a guard that projects beyond the edge of the knife and serves to protect the hide is sometimes used.

After the hair is removed, the hides are placed in water and are usually ready for fleshing the next day.

**40.** The operation of **fleshing** by hand consists in removing the fleshy and fatty matter by means of a sharp knife, and requires great skill. Both straight and curved knives are used in the operation. The hide is thrown across the beam, which has first been covered by a hide already fleshed. The flesh is removed by long strokes of the knife, which is held in a slanting position, the right hand being uppermost. A long, steady drive results in fewer accidents to the hide than a short, choppy stroke. After the flesh has been removed from the main body of the hide, the hide is trimmed with a sharp knife and the shreds and projecting filaments are removed. All the fleshings are saved and sold for glue making.

After fleshing, the hides are hung on individual sticks in vats of fresh water. If the hides are to be used for upper leather, the soaking is dispensed with and the hides at once bated.

The hand method of fleshing and unhairing is too slow, too expensive, and involves too much disagreeable labor to last much longer. Machinery in the hands of skilled operators now does the work at a cost approximately one-third that of the hand process.

**41. Machine Fleshing and Unhairing.**—With machinery, the hides are fleshed either after soaking and before liming or after they come from the limes. If fleshed before liming, they are generally run through the machine again after coming from the limes, in order to remove both the flesh left on after the first fleshing and the flesh raised up by the liming process.



The machines that do the beam-house work are heavy, rigid affairs. The removal of the hair and flesh are accomplished by rapidly revolving rolls, having raised irregular spines on their surface.

**42.** The **Leldgen unhairing machine**, shown in Fig. 7, is the latest and most approved machine for unhair-

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FIG. 7

ing. It consists essentially of a revolving cylinder *d* supported by bearings on a steel frame that moves up and down in the arc of a circle, at the will of the operator, over a flexible bolster *a* on which the hide to be dehaired is placed.

The hide or side is thrown flat on the flexible bolster *a*, the holder *b* is brought down and automatically clamps the

end of the hide or side. The lever *c* is then thrown so as to put the machine in operation. The cylinder *d*, revolving at the rate of 190 revolutions per minute, moves down and up over the hide spread on the flexible bolster *a*. By reversing the lever, the revolving cylinder may be made to travel up and down within the space of 2 or 3 inches. After the hair is removed from one end of the hide, the holder is released, the position of the hide on the bolster reversed, the holder again brought down and the remainder of the hair removed.

FIG. 8

Jets of water from a perforated pipe running behind the holder constantly play on the hide while it is being dehaired.

The cylinder *d* is of cast iron, 6 inches in diameter, on the surface of which steel blades are inserted. The cylinder always revolves in the same direction whether passing up or down over the hide. The bolster *a* is securely fixed at the upper end and suspended at an angle of 45°; at the lower end, by a system of weights and levers, an equal tension is produced at all times over the entire surface. Being supported only at the ends, the bolster is perfectly flexible over

its entire surface, and all parts of the hide (thick and thin) are thereby subjected to an even pressure. This machine will perform the work of six men and with a skilful operator there is little danger of damage to the stock.

**43.** For removing the flesh from the hide, the **Vaughn fleshing machine**, shown in Fig. 8, is largely used in the tanneries of the United States. It consists essentially of a spirally bladed fleshing roll *a*, past which the hide is fed by a rubber-covered bed roll *b* working in connection with a pair of fluted-steel grip rolls *c* and *d*.

The illustration shows the fleshing machine with grip rolls open, ready to receive the hide or side to be fleshed. The operator inserts the hide flesh side up between the parted rolls. A slight pressure on the treadle *e* causes the grip roll *c* to move down through the circular guides and take its place between the grip roll *d* and the rubber roll *b*. All three rolls move forward, thus firmly gripping the hide and holding it in the proper position without damaging it. The revolution of the bed roll *b* and grip rolls *c* and *d* pulls the hide between the bed roll and the rapidly revolving fleshing cylinder *a*, which removes the flesh from the hide as it slowly passes under the cylinder. When the fleshing is completed, the treadle *e* is depressed, and while the rubber and front grip rolls are moving away from the cylinder the middle grip roll is traveling up and back through the circular guides, and the hide is released. One-half of the hide is fleshed from the center to the end, and is then reversed and the other portion is fleshed. The thick rubber covering of the bed roll, aided by springs on which its bearings are mounted, serves to compensate for varying thicknesses of the stock being worked. Similar springs on the bearings of the front grip roll prevent undue compression of the thick parts of the hide.

**44. Bating the Skins.**—The process of **bating** is also called *drenching* or *puering*. To effect the removal of lime left in the skins, the use of *bates*, or *drenches*, is resorted to. The most primitive bate, and one that is widely used today,

is that made from the excrement of pigeons, chickens, or dogs. A fermented infusion of bran is also quite commonly used as a drench.

The *dung bate* or *puer* is prepared by placing the finely divided dung in vats filled with water and allowing the infusion to stand for several days at a constant temperature. The upper part of the liquor is taken for use. The skins are either placed in revolving drums containing the bate or are put in revolving wheels having small openings and which dip in a vat containing the bate as they revolve.

The fermentive action of the bates causes the formation of organic acids that make soluble lime compounds that can be readily removed by washing. It has been found that the action of such bates is bacterial, and recent research work by German chemists has resulted in the isolation of the bacteria forming the ferment.

While in the putrefying liquor, putrefaction begins in the skins, and the fat, dirt, and undergrowth of hair become loosened and are easily removed. Bating causes more or less depletion of the hides; the putrefaction causes the waste of animal tissue and sometimes results in the loss of the entire skin. The bate is not under control, and the hides in it must be carefully watched in order that the putrefaction will not be carried too far to the detriment of the grain of the skin.

45. Various attempts have been made to procure substitutes for these disgusting bates. The problem is to secure an organic acid that will form a soluble lime salt which will not deplete the skin, promote fermentation, nor cause plumping. Hydrochloric acid will readily remove the lime, but of course it causes the hides to become swollen. A mixture of old cheese, glucose, and ammonium nitrate was formerly used; this causes a lactic-acid ferment. Commercial lactic, acetic, and formic acids each have their advocates as deliming agents, and concentrated, fermented whey has lately been introduced for this purpose. Naphthalene-sulphonic acid is the chief constituent of a patented bate that finds quite a

market in the United States. Bates are used mostly on hides that are to be made into pliable leathers. They are seldom used in making sole leather, as the heavy hides are placed in weak, sour, tan liquors, the lactic and acetic acids present accomplishing the same result as a bate, at the same time plumping the hide, and preparing it for a stronger solution of tannin.

**46. Plumping the Hides.**—In making sole leather, where weight is desired, it is advantageous to secure a good degree of plumpness before the hide reaches the liquors that really do the tanning. By **plumping** is meant the swelling of the cells and the distension of the pores of the skin, so that the entrance of the tanning liquor is facilitated. If the hide becomes too plump, hard, brittle leather results; hence, it is very essential that the proper degree of plumpness is attained.

The plumping is done by acids that are either formed in the tan liquors or are added to them. The natural acids formed in a vegetable tan liquor are mostly lactic and acetic. All of them are of bacterial origin, formed by the decomposition of the sugars constituting a part of the non-tannins of the bark. The presence of small particles of hide substance in the liquor furnishes the nitrogen that nourishes the bacteria. If nitrogen is not present, very little acid is found. The absence of the requisite amounts of non-tannins in the liquors will also cause a scant supply of plumping acids. For this reason several so-called *sweet tanning agents* are unfitted for tanning heavy leathers, unless mixed with other liquors rich in non-tannins.

Quebracho liquor is a liquor in which the proportion of the tannins to the non-tannins is so great that acid is slowly formed, and a quick tannage is secured, the leather not being well filled nor nourished. If quebracho is mixed with some liquor with a large non-tannin content, this difficulty is removed. The extracts made from oak or chestnut woods are great acid makers because of the high percentage of non-tannins that they contain.

**47. Methods of Obtaining Plumping Acids.**—In a well-regulated bark yard, the acid formed will be in the proper proportion to the tannin in the liquor, and there is no need for the addition of plumping agents. It sometimes happens, during the cold seasons of the year or when a yard is starting up after an extended shutdown, that the acid is deficient.

Various methods are resorted to in order to help the formation or increase the supply of acid. Crude molasses is sometimes added; a mixture of old cheese, molasses, or glucose, and some nitrogen-containing substance, as ammonium nitrate, will stimulate the production of lactic acid. Commercial lactic, acetic, and formic acids are all used for plumping purposes.

The increasing percentage of extracts used for tanning is gradually causing the tanner to provide means for the development of acid in his yard, and eventually in every tannery the plumping acid will have to be added to the liquors in the form of organic acids, or “grown” in the liquors by the addition of ferments or by the use of acid-forming tanning materials.

**48.** It sometimes happens that too much acid is formed in the yard. The reason for this is not easily determined. It may be because of the season or the weather; it may be caused by the method of leaching, the nature of the water supply, or may be due to other causes seemingly too insignificant to produce such an effect. A tannery where the bark is closely leached will have more acid in the yard than the tannery where there is less regard for economical practices in the leach house. A very soft water or a peaty water will help acid production.

A yard with too much acid is harder to handle than a yard with too little acid. It requires close watching to prevent the production of hard, cracky leather and a consequent heavy financial loss. This condition of the yard may be only temporary or it may be a permanent one. In correcting too great acidity, the *handlers*, or *rockers*, that first receive the

green stock should receive the first treatment. Dilution with weak sweet liquor, or even with water, will help their condition. Soda added to them will, of course, neutralize the acid, and soften the leather hardened by the excess of acid; but care must be taken as to the amount added, for too much soda will make the stock too soft.

The addition of an antiseptic, as corrosive sublimate or carbolic acid, will stop the formation of acid, but will not lessen its amount. The former is the better antiseptic to use, as carbolic acid sometimes tends to darken and spot the leather. Since the antiseptics do not decrease the amount of actual acid present, they are best used in the yard vats to retard the development of acid in that quarter.

49. In a properly managed sole-leather yard, where bark liquors are used, deficiency or excess of acid is unusual. Some tanners pay no attention to this matter, depending on acids introduced into the first liquors for plumping. Commercial acetic and lactic acids are commonly used, and while they accomplish the end for which they are put in, they are unnecessary in a sole-leather yard, where natural means will generally furnish the acid required.

Where the commercial acids are used, continual vigilance must be exercised in paying attention to their strength and the amounts to be used; otherwise, the hides will not be uniformly plumped and the leather will show a corresponding non-uniformity of texture and fineness. With certain classes of hides used in making a special class of sole leather, sulphuric acid is used for plumping. The use of this agent will be discussed in the description of the manufacture of this leather.

50. The plumping is done in the handlers, or rockers, which are vats containing liquors that have been weakened by usage and are well soured. The acids present effect the plumping, and the small quantity of tannin in the liquors serves partly to tan the exterior portions of the hides. To equalize the action of the liquors in these vats, the hides are handled, or rocked, so that all portions of the hide come in

contact with the liquor, and the liquor itself is constantly in motion.

The handlers, or rockers, are generally arranged in sets of a number of vats varying in strength. In handling the hides, it was formerly the custom to lift each hide from the vat and throw it into the next vat in the set, this process continuing through all the vats in the set. It is customary now to tie the hides one to the other, and by means of a hand reel the continuous string of hides is moved from one vat to the other. The *hand reel* is a wooden-stripped cylinder mounted on a stand about 4 feet high and turned by means of a crank. In operation, the reel is placed between two vats, one man turning the crank while another starts the string of hides over the reel and then arranges them in the vat that receives them, the friction of the hides on the reel carrying them along.

Handling by rockers is done by means of a wooden frame hung by pivots in the center of the top of the vats, so as to give a dipping movement of 6 to 8 inches to each end of the frame. The hides are hung over sticks placed across the frame. Motion is imparted to the frames of the rockers by beams connected with overhead shafting. By this means all parts of the hide are kept in contact with the liquor and the liquor is well agitated. This end is also attained in some tanneries by hanging the hides in the vats and agitating the liquor by means of an air pump, which supplies air to the bottom of the vat. The air bubbling up through the liquor keeps it stirred.

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## SOLE-LEATHER MANUFACTURE

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### METHODS OF TANNING

51. The simplest and most typical methods of tanning are those used in the manufacture of sole leather. The tanning of other bark-tanned leathers is accomplished mainly by variations of these methods. For this reason, a discussion of the various processes of tanning in the manufacture



of sole leather will precede the description of processes for the tanning of the skins used in the production of more delicate leathers.

The system at present pursued in the tannage of sole leather is the result of an evolutionary process depending on the selective ability of the tanners themselves. Few scientific discoveries have helped them, and the basic principles of their art have only recently received much attention. This state of things is due to several causes: In the first place, in an art that has attained a high degree of perfection through the endeavors of generations of practical workers, we are apt to rest with the results achieved without questioning the principles involved. In the second place, the raw materials, hide and tannin, being organic bodies of an unknown, or at least of a very complex, nature, there is no foundation for theories of their natural interactions until more knowledge of them is obtained. The methods that have resulted from the evolutionary process of practice serve admirably for the purpose, and by means of them the cost of production is kept so low that the field while perhaps open to scientific criticism is not an inviting one for the prospecting scientist.

**52.** Sole leather is always sold by weight, and the cost of the hide is from 50 to 70 per cent. of that of the finished product. The object of the tanner is to make as many pounds of leather from a given weight of hides as he can possibly produce. His degree of success in this is technically known as **gain**. In the case of green-salted hides, a large percentage of the hide, as it is bought, consists of water and salt and such impurities as dirt, dung, and blood, so that 100 pounds of green salted hides will only make from 60 to 80 pounds of finished leather. The gain would be spoken of as a gain of from 60 to 80. Dry hides contain practically nothing but dried hide substance, and 100 pounds of this class of hides will make from 150 to 185 pounds of leather, the gain in this case being a gain of from 50 to 85.

With green hides, the gain is the amount of leather made from 100 pounds of hides; with dry hides, the gain is the amount of leather made from 100 pounds of hides, less 100.

Clean, dry hide is worth at present figures about 40 cents per pound, and tannin, pure and dry in the liquor, figures about 7 cents per pound. It is therefore essential to get as little of the former and as much of the latter into the finished product as the leather will bear.

53. Vegetable tannage is to a certain extent, no doubt, a chemical process, but after the final chemical reaction between the hide and the tannin has taken place, the product is capable of a further absorption of tannin; the point at which chemical reaction ends and physical absorption begins has not been determined. Suffice it to say that sole leather may contain from 20 to 50 per cent. of tannin, and yet in all cases it may be thoroughly cured and perfectly tanned. There is, however, a minimum limit at which hide treated with tannin is leather, and this limit is the satisfaction of the purely chemical affinity of the hide for tannin.

The whole process is an economical one; the tannin does not change materially while in solution, and it is almost completely recovered from the tan liquors by the hide during the process of tanning. With vegetable tannage, labor costs are low, the only disadvantage being the time consumed and consequent loss of interest on the money invested.

54. There are three general varieties of sole leather made in the United States, the names given them indicating the bark used in tanning. They are *oak*, *hemlock*, and a combination of both, known as *union*. Each of these classes of leather has special modifications represented by special grades of leather. The greater part of the sole leather made in the United States is tanned by hemlock bark. European prejudice against this leather has been removed and immense quantities are annually exported. Hemlock leather is produced by two methods of tanning—*acid* and *non-acid*. Some *slaughter hemlock* is also made, but this forms only a small percentage of the aggregate output.

## OAK-BARK TANNING

**55. Oak Leather.**—Leather made from hides tanned with oak bark is distinguished by its color and texture. Oak bark gives a deposit, or *bloom*, of ellagic-tannic acid on the leather, and oak leather is known as *scoured* or *Texas*, depending on the removal of this bloom.

The hides used are green and generally of native slaughter. The Texas hides are usually from range cattle, are branded, and are made mostly into unscoured leather; those hides which are not branded or have only small brands are used for scoured leather. South American hides make a good grained scoured leather and are in demand for the finest class of men's shoes.

The hides are placed in the soaks for about 3 days, but the time may be shortened by using warm water and a loss in hide substance thereby saved. The water in the soaks is changed with each pack of hides. Some tanners remove the hides after the first day's soaking and replace the dirty water with fresh.

The hides may be fleshed after soaking or they may be put in the limes and the fleshing and unhairing done after they leave the limes. Different tanners have different methods of liming this class of hides. Some leave them in the limes for as long as 5 days, while others complete the liming in 2 days, handling the hides continually with frequent limes. It is claimed that a warm bath of, say, 100° to 110° F. given to the hides the night previous to unhairing is beneficial.

After soaking, the hides may be split along the spine line into two sides, or the splitting may not occur until after liming, and in some tanneries the whole hide is tanned.

After unhairing and fleshing, it is the custom in some tanneries to bate the stock with molasses bate. With the amount of acid usually present in an oak tannery, however, this is unnecessary and is the exception rather than the rule. The hides are usually placed in a vat of clear water and permitted to remain there overnight. The hides are then suspended in the *rockers* and the real tanning begins.

56. The rocker vats are in complete sections, piped so that liquor from the bottom of one vat is delivered to the top of the next. As liquor is supplied to the head, or strongest, rocker vat, it gradually works around through all the vats, being weakened in each by the presence of the hides, until it reaches the weakest, or tail-rocker, vat, from which it flows to waste. The stock is hung in this tail-rocker vat, and is here constantly rocked in contact with the liquor coming from the next vat, which gradually becomes stronger until it is receiving the strongest liquor and has become the head-rocker; the stock is then removed and is ready for the lay-away vats.

The object to be attained with the rocker liquors is the removal of the lime remaining in the grain (it being neutralized by the organic acids in the liquor), the swelling of the hide, and the setting of the color. The quality of the leather is determined by the work done in the rockers and handlers, according as the plumping, coloring, etc. is properly done.

The liquor used in the rockers should be old, mellow, and not strong. The strength of the liquor is regulated by the number of pits in use, so that the green hides should have sufficient acid to purge them of lime and properly start the plumping.

57. From the rockers the hides are taken to the main tanning yard, where the lay-away vats are located. These vats are generally 9 feet long, 7 feet wide, and  $5\frac{1}{2}$  feet deep. In these, the hides are laid out flat, one by one, and a thin layer of ground oak bark sprinkled over each hide. This bark should not be ground too fine, or the weight of the pack will cause the hides to settle together too much and the circulation of the liquor will be prevented, thereby destroying one of the purposes of the bark, and ultimately resulting in imperfectly tanned leather. Each layer is treated in the same way, fresh tan or bark being used in each case.

After laying away has been begun, the tanning is conducted on lines peculiar to the individual tanner. Each man

has his own ideas as to how much liquor the hide should receive and under what conditions. In general, the hides are allowed to remain in a lay-away until the liquor in that vat is sapped. The hides are then removed, the liquor run off, and stronger liquor used after repacking the hides, as before.

Each pack of hides is laid away from four to seven times, according to the theories and judgment of different tanners, the whole operation of laying away extending over a period of from 3 to 5 months. These successive lay-aways are called *layers* and are known as first, second, third, etc. layers, according as they represent the first, second, or third laying away that the hides have received.

58. Tanners differ not only as to the number of layers that oak leather should receive, but also regarding the temperature and strength of the liquor on these layers. For example, the schedule shown in Table I is in effect in a large tannery where oak-bark tanning is employed.

**TABLE I**  
**LAYER SCHEDULE FOR OAK-BARK TANNING**

Layer	Time in Layer Days	Strength of Liquor Degrees Barkometer	Approximate Percentage of Tannin
First . . .	8	34	4.00
Second . .	12	38	4.25
Third . .	16	38	4.25
Fourth . .	25	40	4.75
Fifth . . .	32	48	5.75

59. In another successful tannery where the oak-bark tanning process is used, six and sometimes seven layers are given. The temperatures of the various layers are also kept well up, and if it is necessary to tan the hides in a shorter period, these increased temperatures, with proper regard for the strength of the liquors, will produce the desired effect. Only a few years have elapsed since the use of warm liquors in the yard was inaugurated, and they have not been well

received by all tanners. The schedule followed in this yard is given in Table II.

**TABLE II**  
**LAYER SCHEDULE FOR OAK-BARK TANNING**  
**WITH WARM LIQUORS**

Layer	Time in Layer Days	Strength of Layer Degrees Barkometer	Temperature Degrees Fahrenheit	Approximate Percentage of Tannin
First .	8	34	70	4.35
Second	11	38	75	5.00
Third .	16	35	80	4.60
Fourth	25	40	90	5.15
Fifth .	34	44	100	5.80
Sixth .	48	50	110	6.40

The time taken for tanning by this schedule is a little longer than by the first one given, but the leather seems to be of a closer texture, better filled, and of better wear-resisting qualities.

The first-layer liquor in this yard is an old liquor—the sapped fifth layer—and the second-layer liquor is also an old liquor—the sapped sixth layer. The other liquors are new, sweet liquors made by strengthening oak-bark liquors with chestnut-wood extract.

**60. Oiling and Drying the Leathers.**—When the tanning is complete, the sides are taken from the last layer and thrown into warm water to clean the grain from sediment or fine particles of bark. After rinsing, the sides are piled to drain overnight. They are then swabbed with cod oil, or a mixture of cod and other fish oils, or a mixture of mineral oil and fish oils. The swab used is a piece of sheep-skin tanned with the wool on. The sides are then hung on sticks or by brass catches in the *drying loft*.

The drying loft is generally located over the vat yard; steam pipes are spread over the loft floor and rest on blocks that support the pipes and allow air to circulate around them.

A slat-work floor over the pipes serves as the floor of the loft. Tight windows and ventilators are provided so that the proper adjustment of light and ventilation can be maintained. In some tanneries, the heat and ventilation are supplied by mechanical means, blowers carrying air to the loft and keeping the atmosphere in constant circulation. Without proper circulation the air becomes stagnant among the closely hung leather and the damp leather will become moldy. To aid in keeping the air in circulation, apertures that may be regulated as to size are generally distributed around the floor of the loft. The same end may also be attained by forcing air into the loft at a pressure slightly above that of the atmosphere, thus effectually moving any stagnant air.

The leather is hung over poles whose ends rest on beams, or it may be held by an ingenious brass device in which the weight of the side causes friction to uphold it.

**61. Rolling the Leather.**—When thoroughly dry, the sides are taken from the drying loft to the rolling room and there brushed with water and made into covered piles. When properly tempered, the sides are oiled on the grain side, rolled and dried in the loft, and, when dry, are sorted for the market. The rolling of the leather serves to smooth the grain side and compress the leather, thus making it firmer, and also to put somewhat of a polish on the finished leather. Rolling is effected by machinery.

**62. The leather roller** is a machine consisting of a heavy beam having on its end a polished brass wheel. This wheel is about 8 inches in diameter and has a 6-inch face. A crank gives to the beam a direct motion, allowing the brass wheel to move about 1 foot each way right and left. The leather is held under the moving wheel, or roller, on a small bed of brass conforming to the arc described by the roller. A foot-lever serves to raise this bed and makes the pressure of the moving roller light or heavy, according to the will of the operator. By moving the leather around

under the roller, all parts of it are finally smoothed and polished.

**63.** In some tanneries, the vat sizes of which necessitate it, the hides are split into sides as they come out of the soaks or out of the limes. Whole-hide tannage is more economical as to labor costs in the yard, but side tannage is more economical in beam-house work.

A large, light-colored, and even deposit of bloom on oak leather is considered a mark of fine tannage; for some purposes, the leather is sold with the bloom removed, then being known as *scoured leather*. For this leather, the hides are split and rinsed as usual. Then they are scoured by the scouring machine, drained, oiled, and dried. After this, they are dipped in water, rolled, and dried, and then receive a final rolling before going to the sorting room.

**64.** Most of the "old-style" oak sole leather is made from hides tanned in the manner just mentioned; but there is also sold a considerable amount of "oak leather" that is tanned with oak bark and chestnut-wood extract by methods similar to those used for tanning non-acid hemlock and union crop leather. The leather is bleached, and it is oiled in the wheel instead of by hand; and, except in the matter of tanning materials used, the process of tanning is quite different from true oak tanning.

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#### NON-ACID HEMLOCK TANNING

**65.** In the non-acid hemlock process of tanning, the hides are swelled, or plumped, by the natural ferment acids in the tan liquors, while in the acid process, a solution of sulphuric acid is used to effect the plumping.

**66. Treatment of the Hides.**—With the non-acid hemlock process, the hides used are generally dried South- or Central-American skins. They are well soaked and softened with the help of the hide mill. It is the general practice to soak the hides from 5 to 8 days, then mill them and throw them back into water for another shorter period of softening. They are then milled again and may receive another day's



soaking before the tanner considers them soft enough for good results. After soaking, they are split along the spine line into sides, and the hair is removed by either sweating or liming. After the removal of the hair and fleshing, the sides are soaked overnight in water and are then ready for the handlers. Limed stock is bated in some tanneries, a light bran or hen-manure bate being used. Before putting it in the handlers, some tanners "color" the stock by running it for a few minutes in a paddle wheel revolving in a vat of new, sweet liquor of from 12° to 20° Bark.

**67.** The sides are strung together for handling by tying a shank of one to the shank of the next, and the string of skins is then dropped into the tail, or weakest, handler vat. The handler vats are arranged in continuous sections that are so connected that liquor run into the head vat passes successively through the other vats in the section, flowing from the top of one vat to the bottom of the next. Hand or power reels are placed between each pair of vats so that the string of sides may be easily moved from one vat to the other. The handler liquors are sapped liquor, generally from the first three layers of the lay-away yard; they are weak in tannin and contain the natural plumping acids. The head, or strongest, handler liquors are generally from 14° to 18° Bark., and are sapped by the green stock until the tail, or weakest, handler liquor becomes of a gravity not much above 8° Bark. The strength of the handler liquors depends on the strength of the lay-away yard, which is controlled by the method of the tanner in charge. The stock is put into the tail-handlers and reeled forwards and back, perhaps every hour during the first 24 hours, and possibly eight or ten times during the second day. This reeling serves to change the position of the stock as it lays in the liquor, plunges the liquor, brings every part of the hide in contact with the liquor, and equalizes the effect of the tannin and color on the green stock. After the first 2 or 3 days in the handler liquor, the stock is reeled forwards once every day into a stronger vat until the head-handler

or strongest handler is reached; and, the handler liquors, having accomplished the plumping and started the tanning, the strings are removed and the stock goes to the lay-away yard. Here, the stock receives from five to seven layers in liquors of different strength, according to the methods in use at the tannery.

68. A schedule in use at a successful non-acid tannery is given in Table III.

**TABLE III**  
**LAYER SCHEDULE FOR NON-ACID TANNING**

Layer	Time in Layer Days	Strength of Liquor Degrees Barkometer	Approximate Per- centage of Tannin
First . .	7	21	2.85
Second .	11	22	3.40
Third .	12	23	3.60
Fourth .	18	24	3.75
Fifth .	19	28	4.00
Sixth .	26	28	4.00

In this tannery the liquors are used at a temperature of from 70° to 75° F. on all the layers. The first layer is an old liquor that has been sapped by usage on the fifth layer, and the second-layer liquor is also old, having been sapped on the sixth layer. The third-, fourth-, fifth-, and sixth-layer liquors are all sweet liquors made by strengthening leach-house liquor with extract. The sapped liquors from the first, second, and third layers are used as handler liquors; the fourth layer sapped is returned to the leach house, and the fifth and sixth layers sapped, as just explained, are used for first- and second-layer new liquors, respectively.

The hides are kept in the first-layer liquor for the required number of days. The pack is then hoisted, the old liquor removed for handler purposes, and the hides placed in the second layer. This process of treating the skins to successively stronger tanning liquors goes on until the last layer is reached. The leather is then finished so far as actual

tanning is concerned. The length of time for each layer is a matter determined by the judgment of the tanner, and therefore differs with different conditions. Theoretically, it would be best to allow a pack of hides to remain in a layer until there was no more sapping, or taking up, of tannin by the hides. After the tannin contents of hide and liquor are equal, months of further contact will not put any more tannin in the hide in that layer.

**69. Use of Warm Liquors.**—There is some prejudice against the use of warm liquors in a tan yard, but if the proper limit of heat is not passed, the results seem to be beneficial. By the use of warm liquors, the length of time on the first layers is shortened and stronger liquors used. In one tannery where warm liquors are used, six layers of liquor are given to the stock. The schedule of this tannery is shown in Table IV.

**TABLE IV**  
**LAYER SCHEDULE FOR NON-ACID TANNING WITH WARM LIQUORS**

Layer	Time in Layer Days	Strength of Liquor Degrees Barkometer	Temperature Degrees Fahrenheit	Approximate Percentage of Tannin
First . .	5	28	70	3.15
Second . .	12	30	80	3.40
Third . .	14	32	85	3.60
Fourth . .	18	34	90	4.00
Fifth . .	20	38	100	4.75
Sixth . .	24	40	110	5.00

The liquors at this tannery are made up as follows: The first-layer new liquor is the sapped liquor from the fifth layer; the second-layer new liquor is made by taking equal portions of the sixth-layer sapped liquor and liquor from the leach house. The third-, fourth-, fifth-, and sixth-layer new liquors are made by strengthening leach-house liquors with chestnut-wood extract.

The temperatures on the different layers are adhered to within a range of 5° either way. With these warm liquors, the duration of the tanning process may be shortened, but an increased period does not harm the stock.

With the old process of tanning, the leather, after coming out of the last layer, is thrown into a pool of water to remove the sediment that has accumulated on the surface of the leather. This is also frequently accomplished by placing the leather in a drum with water and revolving it for a few minutes.

**70. Bleaching.**—After the rinsing process, the leather is piled to drain and is then bleached. The bleaching to which sole leather is usually subjected is not really a bleaching process, because the excess of tannin on the surface of the leather, which lightens the color of the stock and also makes it less liable to crack, is simply dissolved and removed. The bleaching consists in dipping the leather into an alkaline bath that dissolves and removes the excess tannin, then into an acid bath that neutralizes any soda remaining on the leather, and finally into water to remove the neutralization product and any remaining acid. For convenience in handling the leather, the three vats are placed in a row, and the leather, hung on sticks supported on a frame, goes into one vat for the desired time. Then, the frame is raised and the leather drained, after which it is put into the next vat. This process is continued until the bleaching is completed. The time necessary for the reaction that takes place in each bath is utilized by the workman in unloading a frame of bleached leather and in loading a frame of leather ready to be bleached.

Sodium carbonate, as sal soda or as soda ash, is the alkali generally used, because it is the cheapest; and, for the same reason of economy, sulphuric acid is the acid always used. The tanner regulates the strength of the bleach by varying the quantity of soda ash or sal soda (and accordingly the acid), the strength depending on the color desired.

**71.** After bleaching, the leather is hung or piled to drain and to dry off slightly before oiling. Hand oiling is now seldom employed, the majority of tanners applying the oil in the oil wheel. The oil wheel is simply a revolving wooden drum fitted with a removable door, and having hollow axles through which the oil is pumped. The oil used is either cod oil, winter-pressed fish oil, or mineral oil, or mixtures of these oils. Many tanners adhere to the use of cod oil, but a good grade of fish oil from which the sediment has been removed by pressing while chilled—or what is known as winter-pressed oil—will give the same results as cod oil and besides is cheaper. The mineral oil is cheaper than either the fish or the cod oil and gives satisfactory results when mixed with oils that are higher priced.

**72.** The color of sole leather is one of the factors that determines its market price, and although it seems the height of folly to demand a qualification that does not affect the quality of a product, yet the extent to which this demand for a good color has been carried has resulted in recourse to means of supplying the demand. In the hands of some tanners, these means have been used for the accomplishment of an end other than the end originally intended, and as a result there is considerable cry about the adulteration of American sole leather. Leather dried in the rough, unless so heavily bleached as to remove too much of its weight, is liable to become dark at certain points on the side. The addition of a small amount of a mixture of glucose, or grape sugar and sulphate of either magnesium or sodium, to the leather, serves to overcome this tendency and results in a leather that dries easily and finishes bright. In addition to these benefits, the leather thus treated will have firmer flanks and bellies, and it remains in better physical condition, so that it can be cut and worked more readily. The amounts of the materials necessary to produce these results in a side of leather are so small that their use for this purpose cannot be called an adulteration. The ease with which these materials can be added, however, has, of course,

resulted in the production of some cheap, adulterated leather.

**73.** The glucose and salts are generally added with the oil in the oil wheel. When the leather is in the proper condition for oiling, it is thrown into the oil wheel and  $\frac{1}{4}$  pound of Epsom or Glauber salts and  $\frac{1}{2}$  pound of glucose for each side are thrown into the wheel. The door is then put on and clamped, the oil pumped in through the hollow axle, and the wheel revolved for from 30 to 60 minutes. At the end of this time, the revolving wheel has caused the tumbling leather it contains to absorb the oil and other materials added, and the leather is removed on trucks to the dry loft, where it is hung on sticks and dried.

For the first day or so after lofting the leather, drying progresses without steam or light, but with proper ventilation. The temperature of the loft is then gradually raised until the drying is complete. This process requires from 10 to 25 days, depending on weather conditions and local loft conditions.

After the leather is thoroughly dried, it is taken down, dipped into warm water, and piled down to "sammy," or to equalize, for from 1 to 2 days. It is then sprinkled with warm water on the grain side, care being taken that every portion is wet, and then swabbed with cod or other fish oil. It then goes to the rollers for a first rolling. After the first rolling, the leather may be hung and thoroughly dried before second rolling, or it may be piled and then second-rolled while in a comparatively wet condition. After second rolling, the leather is hung by one end in the finished-leather loft and, when dry, is sorted and graded for the market.

**74. Wheeling.**—In most of the tanneries of the present, the time of tanning in the yard has been materially shortened and the weight that the hide does not receive in the yard is given it by wheeling with the tanning solutions. The wheels used for this purpose are from 8 to 10 feet in diameter and from 5 to 6 feet wide; they are mounted on trunnions and revolved on a horizontal axis by a pinion

geared to teeth set around the perimeter of the wheel. A removable tight door secured by clamps allows of the loading and unloading of the wheel, and tannin solution is pumped into the wheel through its hollow axle.

The methods of wheeling vary to the same extent as the methods of actual tanning. Each tanner has his own ideas as to the treatment of the stock before and after wheeling, as to the amount, temperature, character, and strength of the tanning solution, and as to the duration of the wheeling. The character, size, and condition of the leather are all factors in determining the kind of treatment to be used, and the tanner's experience tells him what treatment will produce the best results under given conditions.

**75.** After the yard tanning is complete, the leather is thrown into water to wash off any adhering sediment, and it is then hooked out and goes to the *wringer*, which is simply a mammoth clothes wringer provided with brass rolls. The leather is fed in on one side of the wringer and comes out on the opposite side, the surface moisture being removed as a result of the wringing. As the sides of stock come from the wringer, they are piled on trucks, taken to the wheels, and thrown in. The door is put on, clamped in place, and the wheeling material pumped into the wheel. The wheeling materials used include all kinds of tanning liquors, such as chestnut wood, oak bark, hemlock bark, quebracho, sumac, quercitron, and other liquors, varying in strength from 100° Bark. to the undiluted extract running from 42° to 50° Twaddell (210° to 250° Bark.). The temperature at which these materials are used varies from 100° to 160° F., according to the practice of the tanner. After the leather and wheeling material have been put in the wheel, the power is applied and the wheel revolves at from 15 to 20 revolutions per minute, the speed varying according to the diameter of the wheel. The revolution of the wheel causes the leather to roll and fall within the wheel, and being in constant contact with the tanning solution the latter is mechanically absorbed and incorporated with the leather.

**76.** The completeness with which the wheeling material is absorbed depends on the character, size, and condition of the stock and obviously on the amount of the solution added to the wheel. The amount varies from a quantity of solution that represents 1 pound of solids to the side to a quantity representing 4 pounds to the side. The duration of the wheeling varies from 45 minutes to 2 hours, and on the expiration of the required time, the wheel is stopped, the door removed, and the contents of the wheel removed to a truck. From the wheel, the stock may be piled in low, covered piles, it may be hung over sticks in a dark, cool place, or it may be laid away in strong-liquor vats. This treatment is for the purpose of allowing the mechanically added material to thoroughly permeate and equalize its distribution throughout the leather. After piling, hanging, or laying away for the desired period, the stock is taken to the bleach room, and from this point until the leather is finished, the operations are the same as for leather that has not been wheeled.

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#### ACID HEMLOCK TANNING

**77. Acid Hemlock Leather.**—By acid hemlock leather is meant a variety of hemlock sole leather that has been plumped by means of sulphuric acid. Other kinds of sole leather are made from hides that are plumped by organic acids, either naturally present in the liquors or added to them. The sulphuric acid causes an abnormal distension of the pores and swelling of the tissues.

Most of the acid hemlock leather is made from dried hides; that made from green hides is known as *slaughter hemlock sole*, the process of manufacture being the same, except that the hides, being green, are generally depilated by means of lime instead of sweating. The dried hides are largely of South American or of Asiatic origin, this being a very popular method of tanning the Chinese "Buffalo" hides.

The hides are soaked, limed or sweated, depilated, and fleshed in the usual manner and are soaked in clear water. They then go into a weak tanning liquor in what is called



the *coloring vat*. This liquor exerts its astringent effect on the hides to a slight degree, and they are slightly colored by the bath.

**78. Plumping With Sulphuric Acid.**—After the treatment just mentioned, the hides are put into a .1- to .3-per-cent. solution of sulphuric acid and remain in it until the swelling has progressed to the desired stage. They are then ready for the tan yard.

Because of the abnormal plumping caused by the sulphuric acid, the hides can safely be put into strong liquors. In the other processes of sole-leather tanning, the hides receive weak-liquor treatment, the strength being gradually raised until the maximum strength is attained. In this branch of the industry, there are no true rockers, or handlers. The only tannin treatment they receive before going to the first-layer liquor is the slight coloring obtained from the weak tanning solution before plumping.

After plumping, the hides go to the first-layer liquors and are given the time required for this layer. The first-layer liquor in an acid tannery soon becomes impregnated with sulphuric acid and sulphates and must then be discarded. The free sulphuric-acid content is generally not very high in this liquor, but there is sufficient to interfere with the tanning action. The liquors become very dense and the proportion of the tannin to the total solids is low, so that there is little sapping to be obtained. The gravity of this first layer sapped, or "run-to-creek," liquor is from 18° to 25° Bark. and it will contain from .8 to 1.5 per cent. of tannin.

To save the tannin and also to avoid the necessity of running this strong filth-bearing liquor into a stream and contaminating same, has occasioned some experimenting. It has been proposed to remove the sulphates by precipitation with barium chloride and subsequently settling. In some tanneries, it is the practice to run this liquor over a spent leach of tan bark; this removes the free acid and some of the solid impurities.

79. As in the case of the other sole-leather tanning processes, there are various systems in use in this branch of the industry. There is a little more latitude here, however, than in oak or non-acid hemlock tanning, the first-layer liquor being used in many strengths by different tanners. The liquors are made by combining bark and extract liquors according to the present-day practice of all sole-leather tanners; from five to seven layers of liquors are used, either cold or warm. A schedule of strengths in a cold-liquor tannery is given in Table V.

TABLE V  
LAYER SCHEDULE FOR ACID HEMLOCK TANNING WITH COLD LIQUOR

Layer	Time in Layer Days	Strength of Liquor Degrees Barkometer	Approximate Percentage of Tannin
First . . . . .	8	38	3.60
Second . . . . .	11	40	3.90
Third . . . . .	15	42	4.20
Fourth . . . . .	24	42	4.50
Fifth . . . . .	24	44	5.00
Sixth . . . . .	27	48	5.40

The first-layer liquor is a sixth-layer liquor that has been sapped by a tanned pack. All the other liquors are made from leach-house liquor or leach-house liquor strengthened with chestnut-wood extract. The sapped first-layer liquor is run to waste, and the other sapped liquors (with the exception of the sixth layer) are returned to the leach house.

80. In Table VI is given the schedule followed in a warm-liquor tannery using seven layers of liquors.

In this tannery, the first-layer liquor is a sixth-layer liquor that has been sapped, the second layer is a seventh-layer liquor that has been sapped, while the other liquors are leach-house liquors made by building up all sap liquors but

**TABLE VI**  
**LAYER SCHEDULE FOR ACID HEMLOCK TANNING WITH**  
**WARM LIQUOR**

Layer	Time in Layer Days	Strength of Liquor Degrees Barkometer	Temperature Degrees Fahrenheit	Approximate Percentage of Tannin
First . . .	7	27	65	2.50
Second . .	9	29	75	2.80
Third . . .	12	30	85	3.00
Fourth . .	13	32	90	3.20
Fifth . . .	15	34	100	3.40
Sixth . . .	19	34	105	3.80
Seventh . .	28	36	110	4.10

the first and seventh, which are run to waste and to first-layer new, respectively.

After the leather has been tanned in the yard, further treatment is according to the methods described under the head of Non-Acid Hemlock Tanning.

**81. Acid slaughter sole leather** is made from green hides, the hair being removed by either liming or sweating. When the hides are limed, a bate is sometimes used in the production of this variety of leather, but otherwise the liquors and operations are the same as in the manufacture of the regular acid hemlock leather. The use of sulphuric acid as a plumping agent results in the production of a firmer leather. The action of the acid is much more energetic on sweated hides than on limed stock, because in the limed-stock treatment part of the acid is neutralized. Therefore, in the regular acid process, care must be observed as to the degree of plumpness attained.

## UNION TANNING

**82. Union Leather.**—The combination of hemlock and oak barks gives a very serviceable leather known as **union sole leather**. It is of a better texture than hemlock-tanned leather, is tougher, and has a color approaching that of oak-tanned leather. There is probably more variation in the different processes of making this leather than in making other kinds of sole leather.

The color is all important, and many methods are in use for its improvement. Some go back to the leach house in aid of color, and sacrifice tannin there in order to have very pure liquors, which will give the leather a bright, clean shade. An illustration of the wide difference in union methods may be seen in the fact that in some union tanneries the first-layer liquors are as low as 8° Bark., while in others they run as high as 25° Bark. These liquors are not of the same purity, however. The 8° liquor will show a higher proportion of tannin to the total solids than the 25° liquor, but aside from this the tannin strength of the 25° liquor is greater than that of 8° liquor. In tanneries where strong liquors are used, considerable oak or chestnut-oak extract is used, the upper layers being strengthened with it, and the texture and color thereby improved.

**83.** Most of the union leather made is **cropped**; that is, the bellies and shanks are cut from the sides, making the product in the form of rectangular pieces. The crop leather thus made commands a higher price than union side leather, because it can be used without so much waste when being cut into soles. The bellies, shanks, etc. are sold for scrap leather for inner soling, etc. A good quality of cut soles is made from union leather, and the method of selling these cut soles determines the method of tannage in some tanneries. A certain number of soles will be cut from several tannages of leather, and the leather that will give the largest number of soles to a given weight of leather is generally the best seller, if other considerations, as color, firmness, and texture,

are equal. This causes tanners to endeavor to produce a light crop leather of a good color, strength, and closeness of texture. These qualities can be obtained by the use of very pure liquors of low barkometer degree. The purity of the liquor being secured at the expense of leaching, it is questionable whether this method pays, after all. More leather can be made from a ton of bark by this process, but the actual gains will not be so great as when a heavy, well-filled leather is produced.

84. Green, salted hides are used for making union leather. They are well soaked, limed, unhaired, and fleshed, are placed in clear water overnight, and then go into the rockers. According to the method of tanning in use, the rocker liquor and all the other liquors vary in strength. After coming from the rockers, the leather is cropped in some tanneries, while in others it is tanned and finished as

**TABLE VII**  
**LAYER SCHEDULE FOR UNION TANNING WITH**  
**COLD LIQUOR**

Layer	Time in Layer Days	Strength of Liquor Degrees Barkometer	Approximate Percentage of Tannin
First . . . . .	6	14	2.25
Second . . . . .	10	16	2.50
Third . . . . .	10	18	2.75
Fourth . . . . .	12	20	3.25
Fifth . . . . .	15	23	3.75
Sixth . . . . .	25	25	4.50

side leather and then cropped. When cropped out of the rockers, the heads and bellies are strung together and thrown on top of the regular leather in the lay-away vats. From the rockers, the sides go into the lay-away yard; from five to seven layers are given, using oak bark on every layer. The oak bark is ground fine, but not fine enough to prevent circulation of the liquor between the sides in the vats. After

use in the lay-aways, the bark is sent to the leach house and leached with the hemlock bark for the union liquors. It is generally placed on the bottom of a leach, the hemlock bark being run in on top of it.

85. A schedule of layers and liquors in a tannery using cold, weak liquors is as shown in Table VII.

The leather from this tannery is of a very beautiful color, but light in weight, and is tanned quickly. The sapped liquors are strengthened by returning to the leach house, and no extract is used. The liquors themselves are very pure; in fact, some of them are of such purity that 65 per cent. of the total solids are tannins. With this purity, the spent tan, of course, shows considerable tannin, the amount sometimes running as high as 2.25 per cent. The sides are completely tanned here and are cropped after finishing. The yard operations are carried on in the usual manner, the sapped upper layers returning to do duty as lower layers being strengthened in the leach house.

86. To show the difference in methods, the schedule of another cold-liquor tannery is given in Table VIII.

TABLE VIII  
LAYER SCHEDULE FOR UNION TANNING WITH COLD LIQUOR

Layer	Time in Layer Days	Strength of Liquor Degrees Barkometer	Approximate Percentage of Tannin
First . . . . .	7	16	2.50
Second . . . . .	11	21	3.25
Third . . . . .	14	21	3.25
Fourth . . . . .	22	23	3.75
Fifth . . . . .	33	25	4.50

This tannery is a typical, modern, union crop tannery, no oak bark, except that used for dusting between the leather in the lay-aways, being employed. The union color is made by

combining hemlock-, quebracho-, and chestnut-wood liquors, the resulting leather having a good color and all the physical characteristics of union leather. The fifth-layer sapped liquor is used for the first-layer new liquor, the fourth-, third-, second-, and first-layer sapped liquors being used as rocker liquors. The new liquors (except first layer) are made by strengthening the leach-house liquor with equal portions of quebracho- and chestnut-wood extract.

87. A warm-liquor tannery using strong liquors and considerable extract had the schedule given in Table IX.

Six layers were in use at the tannery, although ordinarily but five are given. This tannery makes rather heavy leather, of a good color, and the bark used is well leached. Extract is used for strengthening the liquors, and some are also returned to the leach house for strengthening.

**TABLE IX**  
**LAYER SCHEDULE FOR UNION TANNING WITH WARM LIQUOR**

Layer	Time in Layer Days	Strength of Liquor Degrees Barkometer	Temperature Degrees Fahrenheit	Approximate Percentage of Tannin
First . . .	7	22	65	3.00
Second . .	11	24	75	3.50
Third . . .	14	26	80	4.00
Fourth . .	20	28	90	4.60
Fifth . . .	25	31	100	5.00
Sixth . . .	33	34	105	5.60

88. The use of weak or strong yard liquors depends on the expected finishing treatment of the leather. In a tannery using wheels for the mechanical addition of tanning material to the leather, the yard liquors are generally weaker in barkometer strength and higher in purity than in yards pursuing the old methods of union-leather tanning. After the yard tanning, the leather is cropped, provided this

operation has not been performed previously. It is then finished by rinsing, bleaching, oiling, drying, and rolling, as has been previously described, or, if preferred, it may be wheeled with tanning material, as described under the head of Non-Acid Hemlock Tanning, and then finished in the regular manner. Union crop leather is generally rolled only once, the gloss of hemlock leather not being required on union leather.

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#### QUICK SOLE-LEATHER TANNAGE

89. To tie up the immense amount of money that is represented by the hides in process of tanning by ordinary methods of making sole leather requires either a large working capital or excellent credit. In either case, the interest on this tied-up money is a considerable item in the cost of tanning. Mainly for this reason, **quick-tannage methods** have been and are being devised with the hope of producing a leather as good as the long-tanned product and without the necessity of employing as much unproductive capital as the manufacture of the latter entails.

A large number of quick-tannage methods have been devised, some of these are of proven merit, while others are entirely without value, some few being schemes of unscrupulous promoters. Most of the quick-tannage methods depend on the constant agitation of the hide in the presence of the tanning agent to produce the quickly tanned leather so much desired. It is in the preliminary treatment of the hides and in the strength and method of applying the tanning material that the methods differ. The claims as to time required vary with each process, some being as low as 48 hours from the time the hide leaves the beam house until it is said to be ready for the dry loft.

In one general class of these quick tannages, rockers similar to those used in the first stages of some kinds of the regular-process sole leather are employed. In another, revolving wheels or drums, in which part or all of the tanning process takes place, are used.



**90.** In the processes involving rockers, the stock that comes from the beam house is hung on rockers in the tanning vats. The vats are in complete sections and are equipped with the press system. The top of one vat is connected with the bottom of the next, and the liquor supplied to the head, or strongest-liquor, vat gradually works around through all the vats to the weakest-liquor vat, from which it flows to waste, or to be strengthened. The stock is hung in the vat receiving the weakest liquor, and here it is constantly rocked in contact with the liquor coming from the next vat. The liquor gradually becomes stronger until the vat is receiving the strongest liquor. The stock is then removed and may be put into a strong lay-away vat for a few days, or it may be wheeled with strong liquor or extract, according to the particular quick-tannage process that is being followed. In some processes, the hides receive a chemical treatment before going into the tan liquors. One method calls for rocking in a liquor composed of salt, alum, and sodium nitrate; another, for a light chrome treatment; and others, for still other baths of single chemicals or combinations of chemicals. Treatment with weak organic acids is also generally resorted to, in order to bate and plump the stock before going into the tan liquor. All these chemical baths are designed to open the pores of the hide, so as to facilitate the quick combination of the tanning material with the hide, to prevent the "drawing," or closing up, of the grain when the hide comes in contact with a strong tanning solution, and to taw the hide slightly, so that the absorption of vegetable tannin by the partly mineral-tanned hide is increased and quickened.

**91.** Another general class of quick-tanning processes requires the use of the revolving drum, or wheel, in which to effect the tanning. Various styles of wheels have been introduced and patented, and in many cases the style of wheel or drum used is the only protected feature of the process. The wheels are generally about 10 feet in diameter and are revolved at varying speeds. The interior of

the wheels used in some processes are fitted with arrangements for fastening the hides by one end or edge, so that as the wheel revolves the hides are submerged in the tan liquor at one point of the revolution and stretched out and drained at another point. Another style of wheel has a removable frame shaped like a skeleton wheel, on which the hides are fastened in a parallel row, the frame being then fastened within the wheel, with which it revolves.

Another patented wheel contains a removable frame to which the hides are attached in a parallel row, but which does not revolve with the wheel. The frame is so constructed that the hides fastened to it are stretched in alternate directions by mechanism actuated by the turning of the wheel. The hide frame remaining stationary, the tan liquor is poured over the hides by means of buckets or carriers attached to the interior of the revolving wheel. The buckets scoop up the liquor at the low point of the revolution and dump it at the high point, thus allowing it to fall over the hides attached to the stationary frame.

All the wheels are fitted so as to allow the admission or removal of the tanning material without interfering with their revolution. One process employs a wheel in which the tanning material in the shape of solid extract is placed in latticed receptacles within the wheel, the weak liquor used in starting being strengthened by the slowly dissolving extract. The wheels used in processes requiring heat, or the admission of air or other gases, are so arranged as to permit of meeting all the requirements of the process.

92. In general, the treatment of the hides in quick-tannage processes using wheels is the same as in the processes using rockers. Some processes call for a preliminary treatment, and others begin with the hide just as received from the beam house. Weak liquors are first supplied to the wheels, the strength being gradually increased as the tanning progresses, until the maximum strength of liquor is being used and the wheel tanning is completed. The wheels are sometimes run in sets, the liquor from a wheel contain-

ing hides nearly tanned being run to the next wheel in which the tanning is not so far advanced, and so on to the wheel containing fresh hides. From here, the liquor is run either to waste or to storage to be strengthened. Where the wheel is operated as a unit, each sapped liquor may be run off to give place to a stronger one, or the liquor may be strengthened in the wheel by the addition of strong liquor or extract.

After the wheel treatment, the stock may be bleached and lofted, as in some processes, or it may receive a further treatment by laying away for a few days in a strong liquor or by being thrown loose into revolving wheels containing strong liquor or extract. When the tanning is completed, the leather is bleached, oiled, dried, and rolled in the same manner as the regular long-tanned leather.

**93.** Most of the quick-tannage processes are still in the experimental stage, and they find many opponents among the old-style tanners. The principal objection to the processes themselves is found in the accumulation of weak tanning liquor. The hides are treated so that their affinity for tannin is developed to the highest point, and the strong liquors they receive are sapped quickly; thus, a liquor containing a preponderance of non-tanning matters ultimately accumulates. These sapped liquors may contain considerable tannin, but in the presence of such a large proportion of non-tannins, the tannin itself is not very active and is not available for quick-tanning purposes. The constant strengthening of these liquors serves only to postpone the ultimate end of their usefulness and to increase proportionately the barkometer strength of the waste liquors.

The principal objection to the manufacture of sole leather by quick processes has been its low gain. Unless loaded, or weighted with adulterants, the quick-tanned leather produced at a cost allowing a profit to the tanner does not show the gain that it is possible to make by the older methods of tanning. In the beginning of the quick process, the first leather produced may show up well as to gain and as to cost

of manufacture, but as the process continues it has been the experience of many that gain decreases and costs increase. The waste of unavailable tannin in the sapped liquors and the decreasing purity of the tan liquors are responsible for this condition.

There is also an objection to quick-tanned sole leather simply because it *is* quick tanned, some persons claiming that it is impossible to produce a leather with the toughness, mellowness, and fiber of the long-tanned methods by processes involving a shorter time. This cannot be proved by the characteristics of quick-tanned leathers taken as a class, as leather produced by quick-tannage methods varies in appearance, texture, and strength just as much as the long-tanned leather.

As previously stated, most of the quick-tanning processes are still in the experimental stage, and the exact status of quick-tanned leather is yet to be determined. From present indications, however, it would seem that in the near future the practicability and the economy of the quick tanning of sole leather will be demonstrated; but whether experience will show it to be the equal of the old-style leather remains to be seen.

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#### OAK-TANNED BELTING LEATHER

**94.** Oak-tanned belting leather is really a sole leather, slight changes in the tanning and in the treatment of the leather after tanning being made to produce the tough, mellow leather that is required for belts. The hides should be of the best, and the unbranded packer steer hide is used extensively for this purpose. The beam-house process is about the same as for other oak leather, except that the hide is not split into sides. The hides are thrown over sticks and hung in the handler liquors, instead of being strung together. After coming out of the handlers, the bellies are trimmed off, and sometimes the heads are taken off at this point. The bellies and heads are strung together and tanned separately, or they may be thrown in on top of the regular stock.

After trimming out of the handlers, the hides, or "butts,"

are laid on frames in the lay-away vats, care being used to spread out smoothly and remove all creases. The frames are held by ropes attached to the corners and are gradually lowered into the vat as the height of the hides on the frame increases. This stock is generally given five or six layers, the first, and sometimes the second, being sour liquors that have been sapped by higher layers.

95. The schedule for a typical belting butt yard is given in Table X.

TABLE X  
LAYER SCHEDULE FOR OAK-TANNED BELTING LEATHER

Layer	Character	Strength Degrees Barkometer	Time in Days
First . . . . .	Sour	37	15
Second . . . . .	Sweet	30	10
Third . . . . .	Sweet	33	15
Fourth . . . . .	Sweet	38	30
Fifth . . . . .	Sweet	50	50

The leather is hoisted twice while in the first lay-away liquor, the hides being removed and carefully piled beside the vat. The creases and folds are removed and the hides flattened out in the piling, and the leather is again laid away in the same liquor. This treatment seems to improve the quality of the butts, and while it is not followed in all tanneries, the appearance of the finished product that has undergone this treatment in the yard would indicate that it is worth while. If the leather out of the first layer is flat and free from creases, there is small probability that the higher layers will cause a permanent crease or wrinkle, as the first layer tends to "firm up" the soft stock from the handlers.

After being raised from the last layer, the stock is put into cold water overnight, and then into water at from 90° to 100° F. for the same length of time. It is then taken out of the warm water, carefully piled, and allowed to drain. When

drained, it receives a hand oiling with cod oil on the flesh side and is again piled to allow the oil to work into the leather. The leather is then lightly oiled on the grain side and taken to the dry loft; when dry, it is ready for shipment to market.

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#### HARNESS LEATHER

**96.** Green, salted, heavy cow and steer hides that go through the regular liming process in the beam house are used for harness leather. The hides are bated with chicken-manure bate, with molasses, or with an organic-acid solution. Rockers are used to rock the sides in the first weak tanning liquors. After the rocker treatment, they receive three or four lay-away liquors, oak bark being used between the layers of leather in the vats. The best harness leather is pure oak-bark tanned, but much of the present product is tanned with liquors made up of chestnut-wood and quebracho extract in combination with oak- and hemlock-bark liquors. The flesh is given a smooth surface by skinning, or shaving, when the leather is pretty well struck through.

**97.** After tanning, the leather is scoured. It then receives a light coat of cod oil on the grain side and is hung up to sammy, or season. When properly seasoned, the sides are thrown on the setting table, the flesh smeared with tallow and oil, and the grain side thoroughly worked with a stone. It is then given another coat of cod oil. The flesh side is then worked, additional oil and tallow put on, and the side suspended to slowly dry. When nearly dry, the grain side is again worked, or set, and oiled, and the side is again hung up to dry. From the loft, the leather is piled and remains in the piles for 10 days or more, when it is buffed and blacked. The buffing is generally done by hand, a light shaving of the grain being removed to obtain a uniformly smooth surface. After buffing, a hot solution of sal soda and logwood is applied with a stiff-bristled brush and thoroughly rubbed in. This saponifies the surface grease and

oil, so that it will not interfere with the coloring, and also mellows the grain of the leather. The blacking is then applied with a soft brush, or swab, and is then allowed to dry partly; another application of a thin mixture of oil and tallow or stearin is then given the leather, which is rehung on sticks. After a hand setting-out on the following day, a final coating of oil and tallow is applied and the leather is again hung up to dry. After drying, the sides are removed from the racks and arranged in piles, where they remain from 1 to 2 weeks. The leather from the piles is finished by slicking off the grease from the flesh side and smoothing it, then slicking the grain side, following this procedure by a brushing and finally by rubbing with a woolen cloth. The leather is then trimmed and graded for market.

# MANUFACTURE OF LEATHER

## (PART 2)

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### LIMP, OR LIGHT, LEATHERS

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#### PROCESS OF MANUFACTURE

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##### GENERAL PREPARATION

**1. Introduction.**—In order to make a soft and pliable product known as limp, or light, leathers, the skins used require treatment very much different from that given to the hides in the manufacture of sole leather. The actual tanning is conducted along the same general lines as in the making of sole leather, but with weaker liquors and covering a shorter period of time. With light, pliable leathers the tanning is really the smallest part of the manufacturing process, the finishing of the leather requiring a larger proportion of time and labor. The tanning, however, must be suited to the use for which the leather is intended, as no amount of skilled finishing can entirely obliterate the defects of an improperly tanned hide. Because of the multiplication of operations in making light leathers, processes of manufacture differ to a greater extent than in the tanning processes for sole leather. Every light-leather tanner aims to attain the same result, but methods differ in each department of different tanneries; and nearly every tanner uses methods and formulas differing slightly from the methods and formulas of his competitors, to which differences, constituting so-



called "trade secrets," he ascribes certain real or fancied improvements in his product.

2. As they appear on the market, limp, or light, leathers may have been made from whole hides or skins, or they may have been made by splitting heavy hides into a number of lighter pieces, or splits. If splits are to be made, the



FIG. 1

heavy hides are soaked, depilated, and fleshed in the usual manner and then bated. The hides are then tanned until "struck through" with the tanning liquor. They are then put through wringers to remove the excess of tanning liquor and then stoned on a *stoning jack* to remove the wrinkles. After stoning, the leather is laid in flat piles, and in a short time is ready for the *splitting machine*.





**3. Stoning Jack.**—The stoning jack, shown in Fig. 1, is built of iron and is run by a side belt drive. By means of a crank-shaft, an arm *a* supported and guided by a swinging truss is given a to-and-fro motion, following the contour of an inclined metal bed *b*, the face of which is smooth and cut in the form of a segment of a circle. To the end of the arm is attached the "stone" *c*, which is a rectangular piece of metal with rounded corners and slightly longer than the width of the bed. When in operation, this tool is carried backwards and forwards over the bed at a distance from it regulated by the operator by means of a foot-lever. The leather is thrown on the face of the bed, under the moving arm, and the "stone" brought down on it. By the action of the stone the wrinkles and creases are removed, the leather being moved around under the stone by the operator, so that every part comes in contact with the stone, or smoothing tool. The grain side is finally split, the split being made light or heavy, according to the future use to be made of the finished leather.

**4. Splitting Machines.**—Two general classes of splitting machines are in use, the *Union splitter* and the *belt-knife splitter*. The latter is the more popular machine and is found in most of the Eastern upper-leather tanneries.

In the *Union splitter*, the leather is presented to the edge of the splitting knife by gripping and drawing rollers. It is held on the rollers by carrying arms and is split by the power that rotates the roller by which the leather is carried.

The *belt-knife splitter*, shown in Fig. 2 in front view, and in Fig. 3 in rear view, effects the splitting by means of an endless belt knife *a*, against which the leather is carried by means of rolls. Machines of this type are not automatic, but require skilled labor to operate them economically.

A *skiving* is generally first taken off and the remainder of the hide smoothed out on a stoning jack before further splitting.

FIG. 4

**5. Trimming and Scouring.**—The split is generally hand trimmed before further tanning. Some tanners run the splits in a small wheel with weak liquor in order to remove the glaze caused by the splitting machine. After this they are put back in weak tanning liquor, which is gradually increased in strength until the split is completely tanned.

The grain, which has been almost tanned before the leather was split, is generally gone over by hand to remove any humps, and then the tanning is finished in a revolving drum with the tanning liquor. Sumac and quebracho are favorite tannages for this work, although hemlock is still used.

The finishing of the different classes of leather resulting from the splitting differs according to the part of the original hide from which the split portion has been taken. In some processes, the leather is “worked out” either by hand or on a scouring machine. This is done in order to remove dirt, adhering tan, and excess of tan liquor, and to prepare the face of the leather and set it out by stretching so that after this treatment it is firm, smooth, dry, and even.

**6.** The hand method of scouring is not so common as formerly. Tables sloping from the workmen are used. On these the skins are spread out, and by means of a short-bristled brush, a fine-grained flat stone, and a “slicker,” the laborious operation of scouring is performed.

Because of the labor involved and the expense entailed, the hand method has been largely superseded by machinery. The machine shown in Fig. 4 will scour, or set out, hides for both upper and belting leathers. The skin is placed on the semicircular table *b* and carried up under the revolving roller *a*, which is covered with blades so arranged as to work out the hide and stretch it in both directions at once. The pressure desired is at the control of the operator. The dirt, etc. worked out falls away from the machine, so that it cannot be again taken up by the skin.

**7. “Working Out” Skins.**—For “working out” the skins in different stages of some processes in light-leather

**FIG. 5**

tanning, the serial table machine shown in Fig. 5 is largely used. Machines of this type are also used for unhairing light skins, but they are used mostly for working out and for setting out the skins. Through treatment by this type of machine, most of the water is removed from the skin, the grain is made fine and silky, and the skin is well stretched and left in good condition for oiling and drying.

The rubber-bolstered tables  $a$ ,  $a_1$ , and  $a_2$  are attached to the endless chains  $b$ , and are slowly carried between the double rolls shown at  $c$  and  $c_1$ . The rolls are spirally bladed, and the skins, being carried between the rapidly revolving rolls, are subjected to their action both at  $c$  and at  $c_1$ . As the machine is constantly in motion, the skin is thrown over table  $a$  with its backbone lying along the upper edge. The table is then carried up and passes between the rolls at  $c_1$ . When the table is clear of these rolls, the bolsters and skin are automatically moved so that the backbone, which was not worked between the first pair of rolls, is brought in position to be worked by the second pair of rolls at  $c$ . In addition to setting out the backbone, the upper rolls perform a second working operation on the other parts of the skin. The bolster is now moved back to its original position and the table descends. The skin is then removed, another skin thrown on the table, and the operation repeated indefinitely.

The wet skins are put on the tables at one side of the machine and the worked skins are removed at the other side, so that each operator has the one duty to perform. Recently patented inventions provide for the automatic removal of the worked skin, so that only one operator is needed for each machine.

**8. Clearing and Shaving.**—After retanning the splits in a revolving drum, they are piled for a short time and then *cleared*, or bleached, in a revolving drum. The clearing is generally accomplished by successive liquors consisting of water, a solution of borax, water, a solution of acid, and finally water. In some processes, the clearing is supplemented by a bath of sumac or some other light-colored tanning agent.



For smoothing and leveling the leather, the shaving machine shown in Fig. 6 is frequently used. After the beam-house treatment, or after coming from the splitting machine, the flesh side of the hide needs *shaving* to make a smooth surface and to remove any humps or irregularities in thickness. The machine does far better work than can be done by hand and is much quicker. The shaving is done by a cylinder *a*, Fig. 6, having spiral blades set in its surface. The blades are ground by the emery wheel *b*, which moves



FIG. 6

from one end of the shaving cylinder to the other while constantly revolving. The machine being set in motion by a belt shifter, the skin is thrown over the roll *c*, and pressure on the foot-treadle *d* throws the roll *c* forwards, bringing the skin in contact with the rapidly revolving shaving roll *a*. The skin is moved by the operator so that, by varying the pressure of the skin against the shaving roll, any desired amount of shaving may be done on any portion of the skin. The spines of the shaving roll are constantly being sharpened by the action of the grinding wheel *b*.

After clearing and shaving, the leather is ready for the actual finishing. If it is to have the natural undyed color, it is at once prepared for *stuffing* by treatment on the scouring machine or by slightly drying so as to harden the leather before stuffing.

**9. Stuffing Materials.**—The treatment of leather in such a manner that it will contain an amount of grease or oil such as its future use may require is called **stuffing**. Stuffing is done both by hand and machine, largely by the latter method. The former is used only on certain classes of leather.

For stuffing leather, the oil par excellence is cod-liver oil. It has been in use since the early days of the industry, and as yet no other oil has been found that can satisfactorily displace it. Cod-liver oil has a good body and will not oxidize and form gums, so that it remains in practically the same state in which it entered and gives to the leather a permanent mellow feeling.

This oil is expensive, and therefore adulterations are common. Seal, menhaden, and mineral oils are commonly used as adulterants. Mineral oil may be detected by saponifying the fatty oils by boiling with potash, whereby the mineral oil, which will not saponify, will separate. Mineral oils may be distilled off at about 450° F.

It is almost impossible, with any marked degree of certainty, to detect the fish oil when mixed with cod-liver oil. Fish oils have more gum than the genuine cod-liver oil; but cod-liver oil and menhaden oil have the same color and gravity, and their range of odor and taste is about the same.

Menhaden oil, when cold pressed to remove the foots, is a good substitute for the average grade of cod-liver oil.

Stearin, tallow, beeswax, Japan wax, and paraffin wax are all used for stuffing certain kinds of leather.

Heavy refined mineral oils are largely used for mixing with cod and fish oils for stuffing heavy leather.

Resin oil, obtained by distilling common pine resin, is sometimes used for the same purpose.

Neatsfoot oil is used with satisfaction if a good cold-tested oil is secured; otherwise, a cold temperature will congeal the oil and thus turn the skin white.

Sod oil is largely used for stuffing. It is expressed from skins, and is ready for use after boiling and undergoing clarifying treatment.

Degras is the oil obtained from wool during its cleansing process. French degreas is the surplus oil obtained in the manufacture of chamois leather. It is frequently adulterated, and is put on the market in all grades.

Glycerine is used by some tanners instead of degreas. It imparts to the leather a high degree of softness, but it should not be used alone, as it possesses a corrosive action and, being soluble in water, is easily removed from the leather by dampness.

Porpoise oil is much valued for stuffing.

Wool fat, obtained from the solvents used after extracting wool, is sometimes used as a substitute for degreas.

Olive oil is extensively used in leather dressing, particularly in the preparation of fat liquors.

Castor oil is also largely used, especially in its sulphonated form, known as Turkey-red oil, which is made by treating cooled castor oil with successive small portions of strong sulphuric acid. After standing, the oil is removed and carefully neutralized.

Sperm oil is occasionally used in finishing leather, and it is sometimes used in fat liquors.

The yolk of eggs is used in stuffing high-grade glove leather, as it contains about 30 per cent. of an oil known as egg oil, which is very similar to olive oil.

**10. Hand Stuffing.**—The hand-stuffing method is passing away. The leather must be rather damp for this method that a longer period is required for drying; after the absorption of the oils, the surface must be gone over to remove the unabsorbed matter; then, too, the stuffing penetrates only slightly beyond the surface, and the leather is left dry and hard and practically unchanged.

As practiced, the operation of hand stuffing consists of rolling the sides into bundles, with the grain side in, and softening by heating; then the warm oil and tallow is applied with a brush to the flesh side.

**11. Drum Stuffing.**—In the **drum-stuffing method**, the stuffing is effected by placing the skins and stuffing material in a revolving drum *a*, Fig. 7. The skins are dampened thoroughly on both sides and allowed to lie in a pile, which is then covered with damp cloths. The drum is heated by steam or hot air for some time before receiving the skins. The heat is turned off and the skins placed in the

FIG 7

drum, which is then run for some time with the door loosely closed. This operation loosens up the goods and regulates the temperature. The stuffing material is then run in hot, but not hot enough to scald the skins. The tight door is put on the drum and the skins wheeled for from  $\frac{1}{2}$  to 1 hour. The drum is stopped and the door opened, and the drum is slowly revolved for a few minutes. The skins are then taken out, smoothed, and laid in piles.

They are generally stoned as soon as possible on marble or plate-glass tables (it is best to stone on the grain side first) and then hung up until nearly dry. The operation is repeated on the flesh side, removing all marks of the stone,

and the sides are then hung up until quite dry. There are several patented forms of stuffing drums in which the heating is effected by means of coils containing steam or hot air. The coils keep up the temperature of the drum while the stuffing is going on and do away with the water of condensation.

FIG. 8

A *hot-air stuffing mill* is shown in Fig. 8. The air for the drum *a* is heated by steam coils in the heater *b*, from which the heated air is forced into the stuffing drum by means of a small fan blower, as indicated.

The tannage of the goods and their class, or grade, determine the kind of stuffing to be used. For the best leather, cod-liver oil is generally used. For other and cheaper grades, various combinations of the oils and greases mentioned in Art. 9 are substituted.

**12.** Chrome leather and some bark-tanned light leathers are stuffed with what is called fat liquor. These fat liquors are simply emulsions of different oils, fats, and soaps, the character of which depend on the kind of leather and its future use. Egg yolk is an example of a natural fat liquor.

FIG. 9

For some leathers, a fat liquor made up of water, olive-oil soap, olive oil, degreas, and Turkey-red oil is used. Some tanners use a mixture of water, neatsfoot oil, glycerine, and castor-oil soap, and there are many other combinations of soaps and oils used for fat liquors. The preparation and use of fat liquors is a part of the finishing process that has a

marked influence on the character and quality of the leather produced. Fat liquoring is done in a regular stuffing drum that has been previously heated to the desired temperature by hot air, and the fat liquor may be added continuously during the revolution of the drum.

**13. Buffing, or Whitening.**—The buffing, or whitening, required in the manufacture of some classes of leather is done either by hand or by a *buffing*, or *whitening*, machine. If done by hand, the leather is laid either on a table or on an inclined beam, similar to the beam used in the beam house, and buffed by scraping with a broad buffing tool.

**14. Whitening Machine.**—Whitening by machinery is effected by a machine, shown in Fig. 9, consisting of a rapidly revolving cylinder on the end of an arm having a pendulum motion. The face of the cylinder is covered with parallel knives, or spines, running transversely. The leather is laid on a bedplate under the moving arm, and the arm, with the cylinder, is lowered by means of a foot-treadle until it comes in contact with the leather. The pressure of the tool on the leather is regulated by the operator, who keeps the leather moving so that one section of the surface does not receive more of the abrasive action of the cylinder than another.

The whitening machine illustrated is made of iron. The rotary cylinder, or whitening tool, *a* is driven by belts at either side and running on a small countershaft fixed in boxes at the end of the supporting double truss, or pendulum, *d*. The belt running the countershaft passes between the parts of the truss and over a pulley at its upper end, and thence to the main driving belt. The pitman *e* is connected with the balance wheel *f*, and from it receives a to-and-fro motion. The foot-treadle *b* is for regulating the distance between the cylinder and bedplate *c*, and, accordingly, the pressure on the leather. The bedplate is of polished brass, is slightly wider than the cylinder, and is inclined. A revolving emery wheel *g* travels constantly





from one edge of the revolving cylinder to the other, keeping sharp the faces of the knives, or spines, of the cylinder.

**15. Blackening.**—After whitening, or buffing, the leather is ready for blackening. For the heavy grades of upper leather, this operation is preferably done by hand. The liquid blacking or other dressing to be applied to the surface of the leather is spread evenly over the hide by means of oval brushes made of fine bristles. The excess of blacking is removed by other brushes, care being exercised that no blacking reaches the under side of the leather.

**16. Blackening Machine.**—The most popular machine for blackening leather is the *Batchelder*, shown in Fig. 10, or modifications of it. In this machine, the leather is spread on the table *a* and fed into the machine. The edge of the leather is engaged between the surfaces of two rolls and then passed over a third roll, which forms a supporting bed for the skin, while the brush *b* applies the blacking. The blacking or other dressing is in the receptacle *c*, and the fluted roll *c'* running at the edge of the blacking receptacle supplies the brush with the coloring matter. The brush *d* seems to work the blacking into the leather and also to remove any excess. After passing under the second brush over the supporting roll *d'*, the leather is delivered to a moving bed *e*, formed by endless tapes extended around rollers *f* and *f'* and driven by gears.

As the hide does not always cover the roll supporting it under the blacking brush, some blacking reaches the roll. This roll must be kept clean, otherwise the under surface of a wide portion of hide will become soiled with the blacking. A wiper or cleaner of some flexible material, held by an adjustable bar against the lower surface of the roll, effects the cleaning. The material wiped or scraped from the roll drops into the trough *g* and passes to a bucket provided for that purpose.

The rows of bristles on the brush are so arranged that alternate rows incline in different directions, those of one row inclining toward one end of the cylinder and those of

the next alternate row toward the opposite end. In this way, the ends of the bristles, besides traveling over the leather in the direction of rotation of the brush roller, also, when in contact with the leather, spring in opposite directions longitudinally and thus work the blacking backwards and forwards, as well as in the direction of the movement of the roller, effectually blackening the leather and preventing streaking.

If the leather is to be dyed, the dyeing may take place immediately before or after the stuffing, and in some processes the dye solution is added in the stuffing drum.

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#### DYEING AND FINISHING OF LEATHER

**17.** Aniline colors are well adapted for leather dyeing, and almost all of them are greedily absorbed by leather. Water-soluble anilines are best, giving brighter and clearer shades. The action of the alcohol in dyes soluble only in alcohol seems to injure the fine grain of leather.

Compounds of amyl alcohol are used as solvents for some quick-drying dyes.

Logwood and various other natural dye woods comprise the vegetable coloring agents used on leather. Combinations of aniline and vegetable dyes are frequently employed.

The very large range of shades and tones makes the leather-dyer's task a hard one, and careful management is necessary to secure more than one lot of leather of exactly the same tint. The temperature and strength of the dye bath, the duration of the immersion, the nature of the mordant, and the nature of the tannage of the leather are all factors determining the resulting shade of the finished leather.

**18. Application of Dyes.**—The dyes are applied either by immersing the leather in the fluid, by applying the dye with a brush, by running in a paddle wheel, or by running in a revolving drum. Leather tanned dark is generally bleached before dyeing. The skins are all sorted according to their color, the lightest being used for the delicate shades

of leather. Inferior ones in point of color are colored green, black, or other heavy, dark colors.

When a mordant is used, the nature of the dye to be applied determines the mordant. In leather dyeing, extracts of sumac and fustic, iron sulphate, alum, sulphate of alumina, the tin and copper salts, tartar emetic, and numerous other salts are in use.

In immersion dyeing by hand, the dye bath is generally a little over 100° F. in temperature. The goods are turned over by hand, care being taken that no skin remains long at the bottom of the pile.

In the *paddle method* of dyeing, large paddles that revolve and dip in the vat containing the dye solution are used. This method saves labor, but wastes dye and does not always give a uniform color.

Dyeing in revolving drums is more often done, particularly in the case of chromed calf, sheep, and goat skins.

**19. Dyeing by Immersion.**—In the **hand-dipping method of dyeing**, the progress of the dye can always be watched, so that this method is popular in dyeing leather to match samples. If it is desired to color the grain only, the skin is folded along the spine line, with the flesh side in, pressed together, and passed through the dye in this condition. Or, two skins are pressed together, flesh to flesh, and on immersion the grain side is dyed, very little dye reaching the flesh side. Where a mordant is used, the skins are dipped into the mordant first and then into the dye bath.

**20. Dyeing by Brushing.**—Hand or machine brushing is used on certain classes of leathers and particularly on vegetable-tanned leathers. When a vegetable-tanned leather is to be colored black by the **brushing method**, the leather is laid on the table and a *sig* is first brushed on the surface. The *sig* is simply a solution of an alkali and logwood. It is used to cut any grease on the surface of the leather and to soften and mellow the surface and prepare it for coloring. After the *sig* has been well brushed over the surface, the dye solution is applied and thoroughly brushed in. The dye

solution is made up of logwood extract, soda, and possibly a little fustic extract. The *striker* is then applied and sets the color to the grain fiber of the leather. The *striker* is made of an iron salt, such as acetate or sulphate, and frequently contains a small amount of copper sulphate.

**21.** If an oil blacking is to be given the leather, it is applied and rubbed in while the leather is on the table in one operation, as, from the nature of the pigment, the *sig* and *striker* are not required.

When logwood is used for coloring skins in a revolving drum, the *sig* and *striker* must be used. For coloring the flesh a blue-black or purple, a blue aniline dye is added to the logwood solution, and the *striker* is applied to the grain side only. This gives a blue flesh and a black grain. After coming from the drum containing the logwood and aniline stain, the skins are laid on a table, grain side up, and the *striker* applied to the grain; or they may be doubled over, flesh side in, and immersed in the *striker* solution.

Chrome tanned skins are colored in the same manner, but first receive a mordanting with a sumac or fustic liquor. For fancy aniline colors, the skins are first run in sumac or fustic liquor, then in a solution of tartar emetic, and then, after washing the skins, the aniline dye solution is run into the wheel and the dyeing completed. Black aniline dyes are used in the same manner, and in some instances the vegetable dye is entirely omitted.

**22. Preparation for Surfacing.**—After stuffing and dyeing, the leather is tacked on frames and dried in the dry loft. When dry, the leather is removed from the frames and prepared for *surfacing*. During the *surfacing* operation different seasonings, finishing solutions, and oils are applied to the surface of the leather. For *surfacing* purposes, solutions of casein, flour, algin, Irish moss, gelatine, and spirit-soluble organic compounds are employed.

**23. Staking.**—After light leathers are dried, it is necessary to soften and loosen the fibers so that the leather becomes soft and pliable. This operation is called **staking**,

and was formerly done entirely by hand, the workmen pulling and stretching the skins across a stake, or perch, and using hands and knees in the laborious task. In Fig. 11 is shown a representative type of staking machine by which the greater part of the staking is now done, machine staking having largely superseded the hand method.

The machine consists of a pair of tongs *a* and *a'*, the upper arm *a* having at its extremity two felt-covered rolls *b* and *b'*, between which enters the staking blade *c*, attached to the extremity of the lower arm *a'*. By means of a crank and a connecting-rod *d* the tongs are attached to the crank-wheel *e*, causing the tongs to move backwards and forwards in the

FIG. 11

divided table *f*. A cam actuated by the connecting-rod opens the jaws of the tongs on the forward stroke, and they are closed by springs on the backward stroke. The knee pressure regulator *g* adjusts the pressure of the staking tools on the jaws, so that any desired pull on the leather is at the control of the operator.

In staking, one end of the skin is laid against the roll *h* and held by the pressure of the operator's body, the sides of the skin being firmly grasped by the hands and inserted between the staking jaws of the tongs. The skin is moved about so that all parts are subjected to the action of the staking tools, the pressure or pull necessary for any particular skin, or for any particular part of a skin, being regu-

lated by the lateral movement of the operator's knee against the pressure regulator *g*.

**24. Seasonings.**—The final finishing solutions applied to the surface of light leathers are known as **seasonings**. In addition to giving the finished appearance required by

FIG. 12

the market, they serve as a basis for a glaze and to make the grain surface more elastic. Their composition varies with the class of leather being finished, and many materials and combinations are used in making the seasoning. For colored leather, a mixture of egg albumen, flax, and gum tragacanth is frequently used, and in addition the solution

may contain some of the dye originally used on the leather. Blood, casein, and milk are also used in seasonings for this class of leather. Seasonings for black leathers, in addition to the materials mentioned, often contain bichromate of potash, logwood liquor, isinglass, Irish moss, etc. Skivers and thin skins are often treated to seasonings composed of gums and resins dissolved in alcohol.

The composition of seasonings is really a matter of experience, to be determined by the currier who has watched the effects produced by different ingredients and different proportions of the same ingredients. Each currier has his own formulas for different effects, and probably no two agree on the question of seasonings, except that the seasoning should be applied in very light coats and should be well rubbed into the leather.

**25. Surfacing.**—After being properly prepared, the leather is submitted to a **surfacing process**. The surfacing operation is sometimes performed by hand, but by far the greater part of the leather finished in the United States is *glazed* or *pebbled* by machinery. The operation of the surfacing machine shown in Fig. 12 is similar to that of the rolling machine used in the manufacture of sole leather, but it is lighter in construction. The roller *a* runs in boxes on the end of a beam *b* connected directly to a wheel *c* on the drive shaft, which imparts a direct to-and-fro motion to the beam. The end of the beam is supported by a pivoted truss *d*, which also serves as a guide, so that the roller runs in a line parallel to the face of the bedplate *e*. The bed on which the leather is laid is inclined and its face is straight. On all machines for finishing the surface of leather, every precaution is taken to guard against oil or grease coming in contact with the leather. A single grease spot will greatly depreciate the market value of a skin. The rolls are generally self-oiling and the boxes are especially devised to guard against oil leakage.

**26. Glazing.**—For **glazing**, a smooth roller is used, the leather being laid on the bed and moved around under





the moving roll, so that every part of the surface receives its polishing action. The heat essential to a good polish, or glaze, is supplied by friction of the roll, and the operator must be careful not to maintain too great a pressure on the leather, or the heat generated will burn the leather. The bed is controlled by screws in front of the machine. One screw raises or lowers both ends of the bed at the same time, another screw regulates the pressure for both ends, and the other screws adjust the bed to any desired position.

For the final finishing, a machine in which a piece of smooth, rounded glass is substituted for the roll *a*, Fig. 12, gives the leather a high luster.

An electrically heated roll that has lately appeared on the market has become quite popular. The roller is heated to the temperature necessary for a good polish, so that pressure need not be resorted to in order to produce heat.

**27. Pebbling.**—For pebbling, dicing, graining, or for giving the leather any desired surface, different rolls are substituted for the smooth roll used for rolling and glazing. These rolls have their surfaces cut in the desired figure, and by the action of the machine the design is imparted to the surface of the leather.

**28. Embossing.**—For embossing, a heavier pressure, distributed over a larger area of leather, is needed. The embossing machine shown in Fig. 13 consists of two geared rolls *a* and *b*. The lower one *b* is smooth and forms a supporting surface for the leather that is to be embossed. The upper one *a* is smaller, and the design to be embossed is cut in its surface. The leather is fed between the moving rolls and receives the design from the upper roll. The pressure is regulated by hand wheels *c* and *d* at either end of the machine, and a foot-treadle *e*, connected with a clutch *f* on the drive shaft, assures perfect control of the machine by the operator.

**29.** A large proportion of the graining and embossing of leather is done by embossing presses similar to the

machine illustrated in Fig. 14. A plate in which the pattern of grain or embossing desired on the leather has been cut is attached to and covers the bottom of the heated head *a*. The leather is laid on the bed *b*, and the lever *d* sets in motion the gears that raise the bed along the guide rods *c* until the leather comes in contact with the embossing plate

FIG. 14

on the head. The leather is subjected to enormous pressure, giving it the impression of the particular pattern on the plate. The bed is then automatically lowered, and another portion of the leather is moved on the bed to receive the pattern. The head may be heated by gas, steam, or electricity.

## VEGETABLE-TANNED LEATHERS

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### GRAIN SIDE LEATHERS

**30.** Leathers made from split cow and steer hides tanned by a vegetable-tanning process are used to a large extent in various grades of shoes. The same conditions as to varieties exist with this class of leather as with other classes. The grain split is used with the natural or an artificial grain, and may be stuffed and finished in different ways. The flesh splits, when used for cheap shoes, are grained as desired, and the stuffing and finishing is likewise determined by the future use of the leather.

The sides are tanned in any desired tannage or combination of tannages and, when about colored through, are split to the desired weights and shaved to take out knife marks. The splits are retanned either in the yard or by running in a drum with gambier or quebracho liquor, and are then piled in covered piles for a day or two. After dyeing in the wheel, the leather is "set out" at once or is piled in covered piles to sammy before stuffing. The stuffing is done in a warm wheel, and may be either a straight oil or grease stuffing or a stuffing on the order of fat liquoring. After setting out by hand from the stuffing wheel, the leather is gone over by a whitener, and then receives the blacking coat if black leather is desired. It is then hung up until it attains the proper degree of dryness, and is taken down ready to receive the desired pattern of grain, after which it is hung in the loft to dry. When dry, it is dampened and lightly staked; it then receives the finishes and seasonings required to give it a bright or a dull finish, as desired.

When russet or colored leather is desired, the sides are bleached with borax and acid or with oxalic acid and salt before dyeing. It receives practically all the dye in the wheel, although the seasoning also contains some of the dye to freshen up the color.

## CALFSKINS

**31.** Black and colored shoe leathers made from **calfskins** by a vegetable tannage are manufactured in the following general manner: The skins are soaked, fleshed, and then limed in a mixture of lime and red arsenic or one consisting of lime and sodium sulphide. After removing the hair, the skins are bated in a manure bate, or by means of bran or organic acids. After washing from the bate, the tanning of the skins begins. Various liquors are used in different tanneries, and they are generally combinations of two or more tanning agents. Among the materials used are hemlock, oak, quebracho, palmetto, and gambier. The tanning is done either by hanging the skins on rockers in the liquors or by the use of a paddle wheel. The same general rules for vegetable tanning of heavy leather, as to gradual increasing strengths of liquors, are observed, but the tanning is conducted with weaker liquors and in such a manner as to produce a tough, mellow leather.

**32.** After the tanning, the heavier skins may be split and the splits retanned in a paddle wheel with either gambier or quebracho liquor. The lighter skins are immediately drained, pressed, shaved, and are then ready for stuffing. The stuffing is sometimes done with oils, but more often a fat liquor made of soap and degreas, or soap, oil, and degreas, is used. After the stuffing, the skins are set out by hand or machine and then dried. The finishing is done by dampening the dried skins and then running them in a wheel with sumac liquor, so as to prepare them for the coloring. If a natural or a lighter color is desired, the skins are sometimes cleared by running in the mill first with borax water, following this with an acid solution, and finally washing with pure water, after which they are set out by hand or by machine. For coloring, the skins are first drummed with a fustic-extract solution, and after draining off the extract liquor, the dye solution is added to the drum and the drumming continued until the coloring is complete. The skins are then

rinsed in a weak solution of alum or other chemical, depending on the character of the dye used, to set the color, and are then set out and dried. When dry, they are slightly dampened in sawdust and made soft and pliable by staking on the machine or by hand. Then they receive a coat of paste made up of flour and tallow, and when this is dry the skins are lightly glazed. The seasoning is then applied and the skins are glazed and hung to dry. After this, another coat of seasoning is applied, followed by a glazing. The stock then receives any desired graining, and the leather is ready for the market.

**33.** If black leather having a purple or a yellow flesh side is desired, the flesh dye is put in the drum, and the grain dye is applied by machine, on tables by hand, or by folding the flesh side together and immersing the folded skin in the dye. On vegetable-tanned leather, the black coloring is generally effected by a solution of logwood and soda, followed by a striker solution made of a soluble iron salt. After the grain is dyed, it is washed off with warm water, set out, and a light coat of oil given. The leather is then hung up to dry.

The numerous brands and varieties of vegetable calf leather now on the market are produced by varying the finishing treatment of tanned calfskins as regards the amount and character of stuffing, the character of pastes and seasonings, and the luster and style of grain given the leather.

The general treatment for all these leathers is as just described, variations in details occurring in every factory. No two factories, however, tan or finish leather by exactly similar methods.

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#### WAX CALF

**34.** The class of leather known as wax calf has lost its popularity, and hence is not so extensively made as formerly. This leather is made from calfskins by a vegetable tannage, and is very heavily stuffed with oil, grease, and wax. The

flesh side is shaved and carefully smoothed by hand, and a grease black is applied to this side, the grain side being left uncolored except for the color of the tanning agent used. The finishing is done on the flesh side, and the entire skin receives a final oil soaking and is then rubbed to give it a final market finish. The grain side being next the foot of the wearer of the shoe, the flesh side of the leather is exposed to wear, and scratches or scuffs received are easily concealed by an application of shoe polish. Because of the stuffing made necessary in this class of leather, the clothing is easily soiled on coming in contact with the shoe, and this has helped to decrease the popularity of this wear-resisting leather.

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#### BAG AND STRAP LEATHER

**35.** Vegetable-tanned leather for bags and straps is made from green salted hides. The hides are soaked and split into sides after coming from the soaks. They are then limed, and the hair and flesh are removed either by hand or by machinery. After bating, the sides are attached to sticks and go into the rockers. The rocker liquors contain sufficient fermentive acids to neutralize any lime not removed by the bate and to plump the sides. The small amount of tannin present serves to color the stock and prepare it for the subsequent tan liquors. After the rocker treatment, the hides are moved to the weakest of a series of vats containing progressively stronger liquors. From this vat the hides are moved forwards throughout the series until the strongest vat is reached. After hanging in the last vat the required length of time, the tanning is completed to the required degree. The time required for the tanning varies in different yards, being as low as 15 days in some and as high as 30 days in others. As the sides are to be split, complete tanning is not necessary, but it is essential that the sides should be colored entirely through, so that the splitting knife will have a homogeneous substance on which to work. The liquors are made by combining hemlock and oak barks, myrobalans, chestnut, and quebracho extracts in proportions

determined by cost, character of leather desired, and the ideas of the tanner.

**36.** After tanning, the sides are taken to the wringer and the excess of moisture removed. They are then smoothed out on the stoning jack, when they are ready for the splitting machine. After splitting into as many splits as the size of the side allows, or as the desired weight of the leather being made requires, the splits are trimmed by hand and may be taken to the shaving machine for smoothing and to remove any humps. The splits are then retanned in a revolving drum, or wheel, with extract liquor, quebracho, cutch, gambier, and palmetto extracts being popular for this purpose. The wheel treatment requires from  $\frac{1}{2}$  to 2 hours. From the retanning wheel, the splits are carefully spread out and piled, the piles when completed being covered with canvas and allowed to stand for from 24 to 48 hours, so that the liquor received in the wheel may complete its combination with the hide substance.

After retanning, the leather is "cleared" by being run in a revolving drum, first with water, then with a solution of borax, then water, then a weak solution of sulphuric acid, and finally with another water, each solution being removed before the next solution is added. After clearing, the splits are run in a wheel with a sumac liquor, and occasionally some of the oiling is done in this wheel. The leather is then sorted and different grades assigned for different colors and for different purposes, the grain splits showing no hide imperfections being finished in the natural color for the best grades of leather. When the grading is finished, each lot of leather is dyed the color assigned it, the dyeing being done either in a vat with a paddle wheel or in a tight drum. Leather to be dyed on one side only is of course colored by hand or by the blackening machine.

**37.** After dyeing, the leather is hung over sticks to "harden," or it may be worked out and the excess of moisture removed by the machine. When properly tempered, the leather is worked and oiled by hand on a table. The table

is swabbed with oil, the split being laid on it grain side up. After working out the excess of water and breaking or softening the leather, the grain is lightly swabbed with oil and is then tacked on the drying frames and dried. When dry, it is removed from the frames, moistened to the proper degree, and a light oiling or a seasoning applied. The leather is then thrown over wooden horses and allowed to temper, and may receive subsequent treatments with either seasonings alone or seasonings containing dyes to bring the color to the desired shade. After the seasoning treatment is completed, and when properly dried, the leather is surfaced on a surfacing machine, and may be finished with a glassing machine. It is then "boarded" by hand to break the leather, complete and make permanent its limp character, and give it a particular style of grain, if desired. This is done by light pressure exerted on the cork-faced boarding tool strapped to the arm of the operator, the leather being doubled and the tool moving over the fold of the leather. Different degrees of dampness and different ways of operating the "board" result in different grain surfaces.

**38.** If the leather is to be embossed in imitation of any grain desired, the embossing is done before or after the machine surfacing. The leather should be properly dampened, and, after embossing, it is dried and then boarded.

If the leather is to be blacked, the blacking is applied after seasoning. Three coats of an amyl acetate black are given, allowing one coat to dry before applying the next.

It may be finished smooth or may be dampened and embossed in imitation of seal, or any desired grain, and, after embossing, may be run through a splitting machine to give the particularly light leathers used for card cases, for covering boxes, or for decorative purposes, etc.

The grain split from the hide is made up into the better grades of bag, strap, and fancy leather, while the flesh splits are generally used for cheap bag and strap leather, rough gloves, and innersoling. The flesh splits are frequently dyed, finished, and embossed, and sold for grain leather.



**PATENT, CARRIAGE, UPHOLSTERING, AND EMBOSSED  
LEATHERS**

**39. General Preparation.**—In making patent and embossed leathers for carriage and other upholstering purposes, the heaviest and most extensible of green salted hides are used, as great surface is desired in the finished product. Swiss and Paris hides are popular for such purposes, and hides from these sources are largely made into leather for this class of work.

The hides are soaked, fleshed, limed in straight lime solutions, dehaired, and bated. When ready for the tanning, they are hung by the butt and neck on a rocker frame and rocked in the tan liquor. The hides go into the weakest liquor, the stronger liquor gradually working through the section of rockers until the leather receives the strongest liquor and is sufficiently tanned for the splitting machine. The tanning liquor is composed of a combination of two or more tanning agents, such as hemlock, oak, quebracho, gambier, and palmetto. When the leather is sufficiently tanned, the hide is run through a wringer, or piles of them are pressed in a hydraulic press, to remove the excess of tan liquor previous to splitting. The hides may also be worked on a stoning jack to remove wrinkles and smooth out the surface. A grain split is then taken off the hide. The remainder of the hide passes under the eye of the inspector, who decides as to the number and weights of succeeding splits. The grain splits are then retanned in revolving tight drums with quebracho and gambier liquors, the flesh splits being retanned in open vats, into which revolving paddle wheels dip.

After retanning, the splits are run in a wheel with sumac liquor, and after this treatment they are set out by hand or by machine to remove the excess of water, and while on the table they are given a mixture of degreas and cod oil. The leather is then closely tacked to heavy frames clamped in a stretching machine wherein the wet leather is stretched in all four directions. The frame is then tightly clamped to retain

the stretch, and it is taken to the drying loft, where the leather dries, retaining the increased surface given it by the stretching. When dry, the splits are broken by hand or by machine to make them soft and pliable, and after buffing, if necessary, they are ready for an application of the coating. The grain splits are hand-buffed before being coated; machine buffing is also done by taking a very thin split from the grain.

**40. Daubing.**—The daub, or coating, for the leather is generally made by boiling down linseed oil with the desired pigment and thinning with naphtha. It is quite important that this daub should be properly made, and 2 days is generally required for the operation. The oil is boiled in a large kettle over a coke fire and is constantly stirred. On the first day the temperature of the oil is run up to nearly 600° F. and then lowered to about 380° F. before it is left for the day. On the second day, the temperature is raised a little over 600° F., and the cooking is continued until the desired consistency is attained. The oil is gradually cooled, the fire extinguished, and naphtha added to thin the jelly-like residue; the naphtha is added in small portions with constant stirring. The highest grade of pigments that have been carefully ground in oil are thoroughly incorporated with the daub. All colors of coatings, different degrees of gloss, and varying thickness of the enamel are given to leather desired for different purposes.

The hides, splits, and buffings having been assorted and assigned to the different grades, weights, and classes of finished product, are stretched and tacked to frames and receive a heavy coat of the daub, which is carefully and evenly applied, the excess being removed. When the first coat has dried, a second coat is applied and the frames placed horizontally in the drying oven, where the second coat is dried at a temperature of about 120° F. When this second coat has dried, a thinner coat of the boiled oil is applied, and after this has dried, the surface is smoothed by rubbing with pumice stone. From four to eight coats of the

bottom daub are applied, according to the requirements of the finished leather, and the drying may be done either in the air or in the oven, depending also on the future use of the leather. When the bottom coats have been applied and the surface smoothed, a coat of varnish and oil is applied and dried in the oven. This may be followed by smoothing and the application of a final coat of varnish and oil, and after drying in the oven, and a sun-and-air drying to remove the stickiness, the leather is taken from the frames, trimmed, and is then ready for the market.

Some of the heavy leathers, as for instance the visors for military caps, are coated on two sides, each with a different color.

Various compositions other than boiled linseed oil are now being used for coating the leather, particularly for furniture, fancy embossed, and shoe leathers. Wood alcohol, amyl acetate, acetone, and other solvents are used as vehicles for carrying organic gums, pyroxylin, camphor, etc. in making up coats for shiny leather.

41. Furniture and ornamental leathers receive fewer coats than the heavier carriage dash and automobile leather, and they are given a grain either by boarding, by pebbling, or by the embossing press. The newer compositions for coating are frequently used on this leather.

The buffings, or grain splits from machine buffing, are very thin and are used for bookbinding and for covering boxes, etc. They are coated, colored, and surfaced and may be embossed.

The popular so-called *Spanish leather* that is now so frequently used in upholstering for mission furniture is made by tanning the hides in strong quebracho liquor, which draws the grain and gives the leather its unique appearance. In finishing, it is dyed to the desired shade and coated so that the pigment fills the wrinkles in the surface and accentuates the irregular grain. Spanish leather is also made by embossing the grain of sheep and cow leather and then staining.

Leather for wall hangings, etc. is coated on the frame, then removed, and colors, finishes, and varnishes applied on the table, the leather finally being stamped or embossed with any desired design.

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#### SHEEPSKINS

**42. Sheepskins** come to the tanner salted, either as they are taken from the animal or with the wool removed, the skin having been pickled in sulphuric acid and salt solution. Large quantities of skins are split and the pickled splits are shipped to the tanners in casks.

Sheepskins are made into a variety of leathers and are tanned by processes similar to the methods used for tanning other skins. Considerable sheep leather finds its way into the uppers of shoes supposed to have glazed-kid uppers, and sheep leather is largely substituted for kid and goat leather for other uses. The whole skins are tanned into leather by the oiling process, the chrome process, the vegetable process, or by a combination of mineral and vegetable tannages, the leather being used for shoes, coats, aprons, suspenders, bookbindings, linings, etc. When the sheepskins are split, the grain split is generally tanned by vegetable processes for linings, sweatbands for hats, bookbindings, gloves, etc. The flesh splits, or *fleshers*, are used for making chamois leather.

**43. Preparation of the Skins.**—The wool is removed from the sheepskin by first thoroughly washing the skin and then lightly painting the flesh side with a mixture of lime and sulphide of sodium. The skin is then folded along the spine line, flesh side in, and piled in low piles to stand until the wool slips easily. After the wool is pulled, the skins are washed in clean water and then put into the limes. After liming, the skins are fleshed, washed, and then bated, or drenched, in organic acids or bran. They are then washed and placed in a pickling solution made of salt and sulphuric acid. When the pickling is complete, the skins are removed, allowed to drain, or are pressed, and are then ready for ship-

ment to the tanner. If skivers, or splits, are to be made, the skins are split by a belt-knife machine on coming from the limes. The pickling of the skins preserves them and also *taws* the skins into a kind of white leather.

Sheepskins are very greasy, and to get the best tanning results, the grease must be removed. Sometimes, the skins are pressed during the beam-house operations, thus removing much of the grease before pickling. Hydraulic presses are used and sawdust is sprinkled over the skins to keep them from slipping. The grease is also removed by the use of wringers; naphtha is also used to dissolve out the undesirable grease.

When pickled skins, or splits, are received at the tannery, they are first run in a wheel with whiting and salt, borax, or borax and whiting, in order to remove any acid. They are then washed and given a drenching in a drench made of bran and salt, after which they are ready for the chosen method of tanning.

**44. Tanning of Sheepskins for Rugs, Fur Coats, Etc.**—Many sheepskins are tanned without removing the wool, for rugs, mittens, linings for coats, etc. For such purposes, the skins are well soaked in water and then fleshed. The wool is cleaned by washing thoroughly with a solution of soap and soda and then rinsing in clean warm water. The tanning, or tawing, is done by means of mixtures of alum, salt, and saltpeter. The skins may be allowed to soak in the liquor, or the latter is mixed with bran and the paste spread on the flesh side of the skin, which is then folded and allowed to remain in contact with the paste until the tanning is complete. If white skins are not desired, the tanning may be done in a liquor made of hemlock, gambier, or sumac, which should also contain salt and alum. The skins are frequently handled in the tanning solution, and, when tanned, they are washed, drained, oiled, dyed, and dried. The alum-tanned skins are frequently worked and stretched while drying, so that when dry they will be soft and pliable.

45. If the skins are to be white, the wool is scoured with a strong soap solution, and the skins are hung in tight rooms and subjected to the fumes of burning sulphur to bleach the wool. Chloride of lime and permanganate of potash are also used for bleaching.

In dyeing the wool on either alum- or bark-tanned skins, the wool is first thoroughly washed and rinsed, and the skin is then stretched on a board. The board is lowered into the dye bath so that the wool is dyed, and the wool is then rinsed, carefully dried, and combed. The wool on bark-tanned skins takes a natural dye from the tanning materials used, and this is frequently the only dyeing it receives.

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#### HOGSKINS

46. **Hogskin** leather is extensively used for bags, saddles, footballs, etc. It is readily tanned by any of the vegetable-tanning materials. After the beam-house treatment, the skins are tanned in various combinations of oak, hemlock, quebracho, or gambier liquors, in paddle wheels, rockers, or drums. From 6 to 10 days are required to tan the skins thoroughly, and the leather is then cleared, or bleached, by running in a solution of borax or soda, followed by an acid solution and finally with clear water. It is then given a sumac wheeling, set out by hand, a light coat of oil given, and then dried. After drying, the skins are dampened and shaved, and the heavy skins are split. They are then fat-liquored and slowly dried, and allowed to temper for a few days. The leather is then dampened and dyed in a wheel, set out, oiled, and dried. When dry, it is packed in sawdust and then staked, or gone over with a boarding tool, and after receiving a light seasoning, it is lightly glazed on the machine, when it is ready for shipment.

## MINERAL-TANNING PROCESSES

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### PRINCIPLES OF TAWING

**47.** For making some kinds of white leather, leather for belt lacings, etc. and glove leather, certain agents that are quite different from any previously mentioned are used. Processes requiring the use of mineral tanning agents were originally known as *tawing*, but the term has been enlarged and now includes *chrome tanning*.

In *tawing*, yolks of eggs, flour, alum, salt, and sulphuric acid are used. The hides treated with these agents become tough and pliable, can be stuffed, and will not decompose. Mineral tannages using alum, salt, hyposulphite of soda, and iron salts have been introduced, but with the exception of alum and salt tannages they have not attained any practical value.

**48. Kid-Glove Leather.**—As an illustration of tawing leather, the process for turning lambskins and kidskins into **glove leather** may be described briefly. The skins are thoroughly soaked in cold water for a couple of days and, when soft, are put into a revolving drum in which are fixed wooden pins that thoroughly shift the skins. Water that is run through the drum while it revolves thoroughly saturates the skins and removes the dirt. After washing, they are limed in the lime pits, and the lime is afterwards removed by running the skins over a paddle wheel. They are then depilated and fleshed by hand. After further treatment in the revolving drum, the skins are bated, or puered, in a mixture of bran and water. After being well washed after puering, they are put into the tanning drum with the liquor that is to do the tanning. This is generally composed of flour and the yolks of eggs, or salt and alum, or it may be a composition of three or all of these substances.

After running the drum from 12 to 15 hours, the skins are taken out and hung up to dry and left in the dried condition for several months. This treatment results in better combination of the skin and tawing materials, and the leather is thoroughly tanned. They are then dampened with water and softened by squeezing and pressing by means of swinging planks and finally by drawing the skins individually over a broad steel knife. This operation also serves to remove any of the dry tawing composition that may adhere to the skin.

When ripe, the skins are colored, being first washed in cold water, and are then placed in a revolving drum in a bath of egg yolk. They are treated with a mordant consisting of a mixture of bichromate of potash and soda, and then colored by the addition of sulphates of iron, zinc, or alum, according as black, drab, or tan is desired.

**49. Lace Leather.**—Another example of tawing is in the manufacture of leather for lacing and whips. The hides are soaked, depilated in a mixture of lime and sodium sulphide, and, after fleshing and unhairing, are washed and bated. They are then run in a drum with a mixture of alum, salt, sal soda, and bran. After this treatment, they are hung in the loft and dried, and when dry, are wet down and a mixture of neatsfoot oil, linseed oil, and tallow applied. The hides are then dried and, when dry, are slightly dampened and worked by hand or on the machine until they are soft and pliable. After the application of another coat of oil, they are ready for the market.

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### CHROME TANNING

**50.** A typical example of mineral tannage is the **chrome process**. This tannage is purely a chemical one, consisting of the combination of chromic oxide with the skin. Only from 3 to 6 per cent. of chromic oxide is deposited on the hide. This deposition is evidently a chemical combination between the skin and the oxide, as the product is not affected



by washing or boiling, as are the products of bark tannages; neither is there any deposition of the oxide after the chemical union has taken place, even in the basic liquors used in one of the processes. All chrome leather made is tanned either by the *Schultz two-bath process* or the *Martin Dennis one-bath method*.

**51. Schultz Chrome-Tanning Process.**—The Schultz process of chrome tanning consists in treating the skins to a bath of bichromate of potash in the presence of a mineral acid; following this, a bath of a solution of hyposulphite of soda is given. The theory of this process is based on the formation of chromic oxide, having the formula  $Cr_2O_3$ , which is deposited on and combines with the skins. A solution of bichromate of potash and hydrochloric acid is made up in the proportion of about 5 pounds of bichromate and 2.5 pounds of hydrochloric acid, specific gravity 1.16, to every 100 pounds of wet prepared skins.

The reaction expected between the acid and the bichromate is



However, in the process, only two-thirds the acid necessary for the complete reaction is present, and it is not safe to say, considering the peculiar properties of chromium, that this formula represents the reaction.

After the hides have been in this bath, they are put into a solution of hyposulphite of soda with a free acid; this effects the reduction of the  $CrO_3$  to  $Cr_2O_3$ . To neutralize the acid remaining in the skins, they are afterwards wheeled with water containing suspended calcium carbonate, or a solution of borax or sal soda.

**52.** The use of practically all the agents that will reduce  $CrO_3$ , as hydrogen sulphide, the sulphides and acid bisulphites, etc., has been patented. Sulphurous acid seems to be the best, or at least it is the one most generally used. Norris has patented the use of zinc in the hypo bath, which, it is claimed, accomplishes a more rapid and economical reduction.

Amend has a two-bath process in which chromic acid,  $H_2CrO_4$ , replaces the bichromate and an acid of the Schultz patent; this requires careful manipulation. He suggests the use of aniline as a reducing agent.

A chalk bath after the tanning bath neutralizes the hydrochloric and sulphurous acids remaining in the skins; solutions of sal soda and borax are also used for the same purpose. Norris has patented the use of potassium permanganate for this purpose. This salt not only oxidizes the sulphurous acid to sulphuric acid and neutralizes it at the same time, but it also precipitates the oxide of manganese on the skin, and this acts as a mordant in subsequent dyeing.

**53. Dennis Chrome-Tanning Process.**—The Dennis process of chrome tanning apparently offers less difficulty than the two-bath system, but it has not come into such general use; it seems to be better adapted to delicate skins than the Schultz process.

In the Dennis process only one bath is used; this is composed of a solution of a basic chrome salt that readily yields its excess of chromic oxide to the hide tissues. The tanning liquor used in this process is made by dissolving oxide of chromium in hydrochloric acid, thus forming the normal chloride. To this is added an alkaline base, as sal soda, and this stronger base takes from the chromium chloride part of its acid, leaving the oxy, or basic, salt. This basic salt is a very unstable compound and readily yields its excess of chromium to anything having any affinity for it, which in this case is the hide substance. The advantages of this system over the two-bath system are as follows:

1. One handling of the skins is saved, because one bath only is needed for the tanning.

2. The skins are not exposed to the destructive action of chromic acid, and are therefore stronger, with more lasting suppleness, and have a better grain.

3. There are no offensive fumes evolved in this process; the reduction of the oxide in the two-bath process is accompanied by a strong odor of sulphur dioxide.

4. The skins are not harmed by too long contact with the tanning liquor.

5. Less skill is required to operate it and the bath itself is cheaper.

**54.** The practical operations of tanning by means of the Dennis system are as follows:

The calfskins or goatskins are soaked, limed, depilated, and fleshed as usual and placed in a bran drench. From the drench they are taken to a drum and milled with a strong solution of alum and salt. This keeps the skins open and plump and also has the effect of keeping them in good condition during and after the tanning. From the alum-and-salt bath they are put in the tanning bath, which contains a 3-per-cent. solution of the concentrated basic chrome liquor and also a liberal quantity of common salt. This common salt prevents the grain of the leather from drawing under the astringent action of the chrome bath.

When the skins have assumed a uniform greenish-blue color and a cutting reveals the completion of the process, they are rinsed off in clean water and worked on the flesh side with a slicker on a perfectly clean table. The bath of suspended chalk may or may not be used, at the option of the tanner.

**55. Characteristics of Chrome Leather.**—Chrome leather has special and peculiar qualities that distinguish it from other kinds of leather, making it a superior article. It is not actually waterproof, but rather a moisture resister; it is a difficult matter to wet it thoroughly when once perfectly dry.

The ordinary bark tannages are compounds of two organic materials and when they are subjected to alternate wetting and drying they will eventually deteriorate and become rotten. Chrome leather, being a combination of an inorganic material with the hide substance, is not affected by wetting and drying. It is lighter than bark leather and also possesses more elasticity and is of greater strength.

**56. Finishing of Chrome Leather.**—The finishing, or currying, of chrome leather is carried out with some modifications of the methods for finishing bark leather. Chrome leather must be stuffed soon after removal from the tanning bath and must not be allowed to become dry. The most efficient way of stuffing chrome-leather hides is by “fat liquoring.” There are different ways of making and using these fat liquors, depending on the quality of the leather to be produced. The fat liquor commonly used is an emulsion of neatsfoot oil with a potash soap; it is used warm and applied in a revolving drum. Emulsions of egg yolk and degreas, or egg yolk and olive oil, are frequently used. Chrome leather is lubricated and nourished better by these fat liquors than by the hard greases and heavy fish oils that are used in bark-leather stuffing.

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## MINERAL-TANNED LEATHERS

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### CHROME CALF

**57.** There are on the market many varieties of **chrome calf leather** that are sold under different trade names. When these varieties of leather represent the product of straight chrome tannages, the actual tannage of each particular brand is carried out in about the same way, the differences that characterize them being due to the amount and character of stuffing, character of the finish, and the style of grain given the finished leather.

**58. Box Calf.**—The variety of leather known as **box calf** is generally made in the following manner: The skins are soaked, limed in a mixture of lime and red arsenic, or of lime and sodium sulphide, fleshed, dehaired, and then bated, or drenched. They are then pickled in a solution of sulphuric acid and salt and tanned by either the one-bath or the two-bath chrome process. The skins are then pressed in a hydraulic press, or worked out by hand or machine, and then shaved to give the flesh side a smooth surface. They are

then stuffed, or fat-liquored, and colored. After hand or machine setting out, to remove the excess water, they may be tacked to frames for drying, or they may be dried simply by hanging them over poles in the loft. When the leather is dry, it is packed in damp sawdust, and when properly dampened, it is staked by machinery. Some tanners dry the leather from this staking and then give it a second staking. After the staking, the leather receives a coat of seasoning made up of copperas, logwood, glycerine, and albumen, and when the leather is dry, it is glazed on a glazing machine. Other coats of seasoning, followed by glazing, are sometimes given before boarding. The "box" grain of the leather is given by a workman, who has a cork-covered boarding tool strapped to his forearm. The boarding tool is applied to a fold of the leather, and the characteristic grain is imparted to the leather by the motion and pressure of the workman.

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#### GLAZED AND DULL KID

**59.** Goatskins imported in a dried state are used in making both glazed and dull kid, although some sheep leather and even some light grain splits are sold to be used in "glazed-kid" shoes. The dried goatskins are well soaked and then painted on the flesh side with a mixture of sodium sulphide and lime. This attacks the roots of the hair, loosening it and causing it to slip easily. After painting, the skins are folded along the spine, flesh side in, and piled in low piles to lie overnight. In the morning the hair is removed and the skins are then limed or treated with sodium sulphide. If limed, a mixture of lime and red arsenic is used; if sodium sulphide alone is used, the skins, after dehairing, are washed in paddle wheels to remove the lime and sodium sulphide used for dehairing. After washing, the hides are run in a paddle wheel with sodium sulphide until they are in proper condition. They are then well washed with water, and finally neutralized with a solution of boric acid. After fleshing, the skins are bated, or puered, in a dog-manure puer to the proper condition for tanning, and

then thrown into borax water. Either the one- or the two-bath chrome process is used for tanning, the latter being the more popular. After being run in the first bath in a drum, the skins are removed and set out on a machine, or pressed in a hydraulic press, to remove the excess of water. They are then dipped by hand in a solution of hydrochloric acid and hyposulphite of soda and piled in covered piles. This hand dipping is for the purpose of reducing some of the chromium solution on the surface of the skins. The next day the skins are taken from the piles and run in a drum with the second bath, which reduces and fixes the chromium oxide on the fibers.

60. When the reduction is complete, the skins are run with borax or soda solution until the free acid has been neutralized, and finally they are washed with clean water. The skins are then set out by hand or by machine to remove the excess of water, fat-liquored, and given the desired color, after which they are worked by hand or machine to remove moisture and to give them a soft silky grain and also to stretch them. The skins then receive a light coat of glycerine, or of glycerine and oil, on the flesh side and are dried on poles in a warm drying loft. When thoroughly dry, they are taken to an airy loft, thrown in piles, and left to temper for 7 or 8 days, during which time they absorb atmospheric moisture and soften. After tempering, the skins are packed in damp sawdust, which brings them to a proper condition for staking. The staking is done either by hand or by machine, the smaller and lighter skins being generally hand-and-knee staked, while the machine is used on the larger and heavier skins. After being thoroughly "broken" and softened by the staking, a coat of heavy seasoning is applied, and after this is dry the skins are lightly glazed on a glazing machine. Seasonings vary in composition with the finisher, but they are generally compounds of such materials as blood albumen, egg albumen, algin, etc., and are colored to match the color of the leather that is being finished. After the first seasoning and glazing,

a second coat of lighter seasoning is applied, and the leather receives a heavier glazing on the machine. A final light coat of seasoning is applied, and the skin is then glazed with a heavy pressure, after which the skins are laid away to be inspected, sorted, measured, and packed for shipment.

**61.** For dull-finished leather, a heavier stuffing, or fat liquoring, is given the most perfect of the skins and, instead of being glazed by the machine, they receive a light coat of paraffin oil and are ironed by hand with a hot flatiron. They may then receive another coat of oil and receive a final ironing.

**62.** **Chrome side leather** is made by soaking, liming, unhairing, fleshing, and bating the whole cowhide, and then pickling it in salt and sulphuric acid and splitting. The grain split is then chrome-tanned and the subsequent finishing processes are the same as for either glazed or dull kid. Heavier grain splits may be tanned and finished in a manner similar to that employed with chrome calf, and frequently the entire cowhide is chrome-tanned before splitting.

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#### CHROME PATENT LEATHER FOR SHOES

**63.** Whole skins, such as calf, goat, and kid, or split cowhides and steer hides are used in making enameled, or patent, leather for shoes. The skin or hide may be tanned by vegetable as well as by chrome-tanning processes. The actual tanning processes for leather to be coated are similar to the methods of tanning different skins or hides into other light leathers. The stuffing and seasoning vary somewhat, but up to the point of enameling, the process is not materially different.

**64.** A patent shoe leather made from chrome-tanned cowhide splits is made by the following process: The hides are soaked, split into sides, fleshed, depilated with sodium sulphide, washed, and bated. They are then pickled in a solution of sulphuric acid and salt, and are either pressed or put through a wringer and then sent to the

splitting machine. The grain split is used for making the patent leather, and after being shaved on the machine to give it uniform thickness and to make the flesh side smooth, it is tanned by a two-bath chrome process. It is then fat-liquored and colored, the flesh receiving a purple color before the main dyeing takes place. After setting out by hand or on the machine, the grain side receives a light oiling, and the split is then sent to the loft and dried. When dry, it is packed in wet sawdust and then staked by hand or by the machine to make the leather soft and pliable.

The leather is now ready to receive the enameling compounds. These are made in various ways, the pastes used on the first coats being generally made by boiling down linseed oil with lamp black and then adding naphtha to thin them. Other oils and mixtures are now used for this purpose, and their ingredients differ with each foreman, who endeavors to keep his competitors from securing his formulas. The leather is stretched and tied to frames, after which the first coat of daub is rubbed on and worked over the surface evenly, all surplus being removed by means of a slicker. When the first coat has dried, a second coat of the same material is applied in the same manner, and the frame, with the leather, is placed horizontally in a huge oven to dry. If other coats are to be applied before the top varnish, they are put on after this drying and the frame returned to the oven. When the leather is ready for the top varnish, it is gone over with pumice to make the surface perfectly smooth and to remove pimples. The dust from this operation is brushed off the leather, or blown off by a jet of compressed air. The top varnish is applied in a warm, dust-proof room, into which the ovens open. It is thinner than the previous coating solutions and varies in composition. Linseed oil, organic gums, pyroxylin, or guncotton, camphor, amyl acetate, wood alcohol, and castor oil are among the ingredients of the various daubs and varnishes used for coating leather, and probably no two factories use the same formula. The top varnish is applied to the leather with a broad, long-bristled brush similar to a whitewash brush. In applying



this top coat, great care is taken to spread it evenly and to leave no bubbles or dust or hair marks.

After receiving the top varnish, the frame is placed in the oven and the skin dried, and after the oven drying it is taken into the air to receive a final sun-and-air drying, which removes any tendency to stickiness. When thoroughly dried, the finished leather is cut from the frame, trimmed, and measured; it is then ready for shipment.

The desired grain for enameled leather is given to it by a pebble roll, or by embossing before the final coatings are applied.

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#### CHROME SOLE AND BELTING LEATHER

**65.** Chrome sole and belting leathers are being made in constantly increasing quantity, although as yet this class of tannage has not become common. The sole and belting leather produced by the chrome-tanning process has not the weight of the bark-tanned leather it aims to supersede, and its cost is accordingly higher. The cowhides or steer hides from which these kinds of leather are made go through the regular beam-house processes, and they are then bated with organic acids so that all the lime is removed from the hides. Then, they are pickled in a solution of sulphuric acid and salt, and when drained after removal from this solution they are ready for the tanning. The one-bath chrome process has thus far been found most suitable for this class of leather. The hides placed in the vats are suspended on rocker frames and rocked, as in some classes of vegetable sole-leather tanning. After being tanned, the hides are removed, washed thoroughly, and then set out by hand or on a table machine. After this treatment, they are shaved and are then ready for stuffing. The first stuffing is done by a fat liquor or a soap liquor and, having received this stuffing, the hides are piled to drain overnight. The hides to be made into belting are then heavily stuffed with a mixture of such materials as paraffin, degreas, stearic acid, vaseline, and beeswax, and piled in covered piles to lie overnight. The next morning they are set out by hand or by

machine, and then clamped on stretching frames to dry. When dry, they may be shaved and glazed, if desired.

The hides to be made into sole leather are not so heavily stuffed as the chrome belting leather, but are frequently filled and weighted with barium, magnesium or sodium sulphates, casein, Irish moss, and similar materials. The drying is done on light frames, and they are not subjected to the stretching given to the belting leather.

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## COMBINATION AND OIL-TANNED LEATHERS

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### DONGOLA LEATHER

**66.** An example of a combination vegetable and mineral tannage is found in the so-called **dongola leather**. Originally, the dongola tannage was a combination of alum and gambier, but dongola leather is now made with other vegetable combinations besides gambier. Hemlock and oak liquors are sometimes used in combination with gambier, and quebracho extract is also a popular material for use with the gambier. This class of tannage is applied to calfskins, sheepskins, goatskins, and kidskins, and side leathers are also made in this way.

**67. Preparation of Dongola Leather.**—After coming from the beam house, the skins are bated and washed and then pickled in a solution of sulphuric acid and salt. After pickling, the skins go into the tan liquor, which is made up of gambier, gambier and quebracho, gambier and hemlock, etc., to which is added a solution of alum and salt. The tanning takes place in rockers or in paddle-wheel vats. In some tanneries, the stock is given the mineral and the vegetable tanning, the skins being first tawed in the alum and salt liquor and then tanned in the vegetable tan liquor.

After tanning, the leather is washed in a wheel, pressed or wrung, and then shaved; if splitting is necessary, it is done at this stage. Sometimes, the heavy hides are split out of

the pickle, the flesh splits being tanned by a dongola process, while the grains are finished by a chrome process.

After shaving or splitting, the leather generally receives a wheel treatment with a pure gambier or sumac liquor. Splits are retanned in gambier or quebracho liquor in a wheel, or may be returned to the original tanning vats.

From the sumac wheel, the leather is piled on horses and allowed to drain overnight; or, it may be set out immediately and then stuffed. The stuffing is done by a fat liquor generally made of soap, cod oil, and *degras*. Frequently, the leather is given two stuffings, the first being a straight-oil combination, such as neatsfoot and cod oils. Then, after drying and redampening, the leather is again stuffed with a fat liquor. After stuffing, the leather is dried. When dry, it is dampened in a wheel with warm water and is then colored and finished according to the character and appearance desired in the finished product.

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#### CHAMOIS LEATHER

**68.** The so-called **chamois leather** is made from the "fleshers," or flesh splits, of sheepskins. The splits are thoroughly washed and may be bran-drenched, after which they are pressed to remove the excess of water. They are then thrown into a heavy machine similar to the hide mill used in sole-leather tanneries and worked with cod oil or a good grade of fish oil. Several additions of oil are made while the skins are being worked in the beaters, and the operation of beating consumes considerable time. When the operation is ended, the skins are removed from the mills, or beaters, and arranged in piles or hung in closed rooms. This causes the skins to heat, completing the oxidation of the oil that has been beaten into the skins. After this treatment, the skins are placed in a hydraulic press and the excess of oil and grease is pressed out. The product of this pressing is known as *degras* and is used in the finishing of many kinds of leather. After this pressing, the skins are washed in a solution of sal soda, which saponifies any remaining oil

and grease. The soap thus formed is treated with weak sulphuric acid, which releases the oil. This oil is the *sod oil* of the currier. After the removal of the oil, the skins are washed, dried, staked, and made smooth and pliable by working, when they are ready for the market.

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#### OIL-TANNED SHEEPSKINS

**69.** Another example of an oil-tannage production is the old **Napa leather**, which is really a soap-and-oil-tannage product and not the result of a pure oil tannage, as is chamois leather. The wool is removed from the skins by painting on the flesh side with a mixture of lime and sulphide of sodium, and the skins are then thoroughly washed and then pressed in a hydraulic press to remove the grease. The skins are then run in a revolving drum containing a solution of salt and sal soda, or potash. From this solution, they are removed and pressed, or wrung, and are then run into a drum with a solution containing soap and neatsfoot oil. When this solution has penetrated the skins, they are removed and pressed. The heavier skins are returned to be retanned, while the lighter skins are colored and dried. When dry, they are moistened and staked and then stretched and tacked on frames and thoroughly dried. When dry, they are buffed, or shaved, and finished to the desired dull or glazed finish.

This leather is soft and possesses considerable strength, being largely used for linings, bookbindings, and as trimming for fancy braces and suspenders.

## MEASUREMENT OF LEATHER

**70.** Sole leather is always sold by weight, but light leathers are sold by area, the approximate thickness also being taken into consideration. The measurement of leather is now usually done by means of machines, of which there are

FIG. 15

several on the market. Some of these vary essentially in principle, but the descriptions of the Sawyer and Union measuring machines given here will be sufficient to show their application.

**71. Sawyer Measuring Machine.**—The Sawyer leather-measuring machine, shown in Fig. 15, is run by power. The leather is fed between two rollers that smooth it out and bring it into contact with small measuring wheels. The movement of these wheels influences properly arranged levers, which, in turn, affect the index of the registering mechanism.

FIG. 16

**72. Union Measuring Machine.**—The Union leather-measuring machine, shown in Fig. 16, consists of a table with a top made of parallel sticks of wood. A hinged cover closes over this, and throughout the entire surface of this cover are suspended small wire pins that are free to slide up through holes in the cover. The pins are arranged in rows, so that when the cover is down, with

nothing between, the pins hang between the strips of wood forming the lower table.

When leather is to be measured, it is placed on these strips and the top brought down over it. The surface of the leather obstructs the small pins and throws them up, the ends of the remaining pins dropping between the strips. These pins are of such sizes and weights that each exercises the same force on a spring balance above, so that this device is affected by the number of pins obstructed by the leather. The weight of forty-eight of the pins corresponds to a square foot of area, and the dial of the balance indicates, in fractions of a square foot, the weight released by the leather, and consequently the area of the leather.

A machine that measures the leather in all three dimensions was patented recently, but as yet it has not been put on the market.

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## ANALYSIS OF TANNING MATERIALS

73. The methods of analysis for tanning materials have been gradually developed and are peculiar to this class of work. In addition to the general laboratory equipment of apparatus and chemicals, there are needed special contrivances and preparations, such as extraction apparatus, devices for shaking, animal charcoal, and a supply of hide powder.

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### ANALYSIS OF BARK, WOOD, ETC.

74. **Preparation and Extraction of Sample.**—The sample is ground so that it will pass through a sieve having 20 meshes to the linear inch. It is well mixed, and a 10-gram sample is dried overnight in a steam oven for moisture determination. A weighed portion of the bark is then extracted in some form of extractor suited to the nature of the material under examination. In all cases, the extractor should be of such form as to permit the removal of the first, or strong, portions of the extractives, so that these will not be subjected to the influence of sustained high

temperatures. For materials like oak and hemlock bark or chestnut wood, a different method of extraction from that required for sumac, algarahilla, etc., may be used.

**75. The Reed Extractor.**—An extracting apparatus suited for use on all materials is that known as the **Reed**

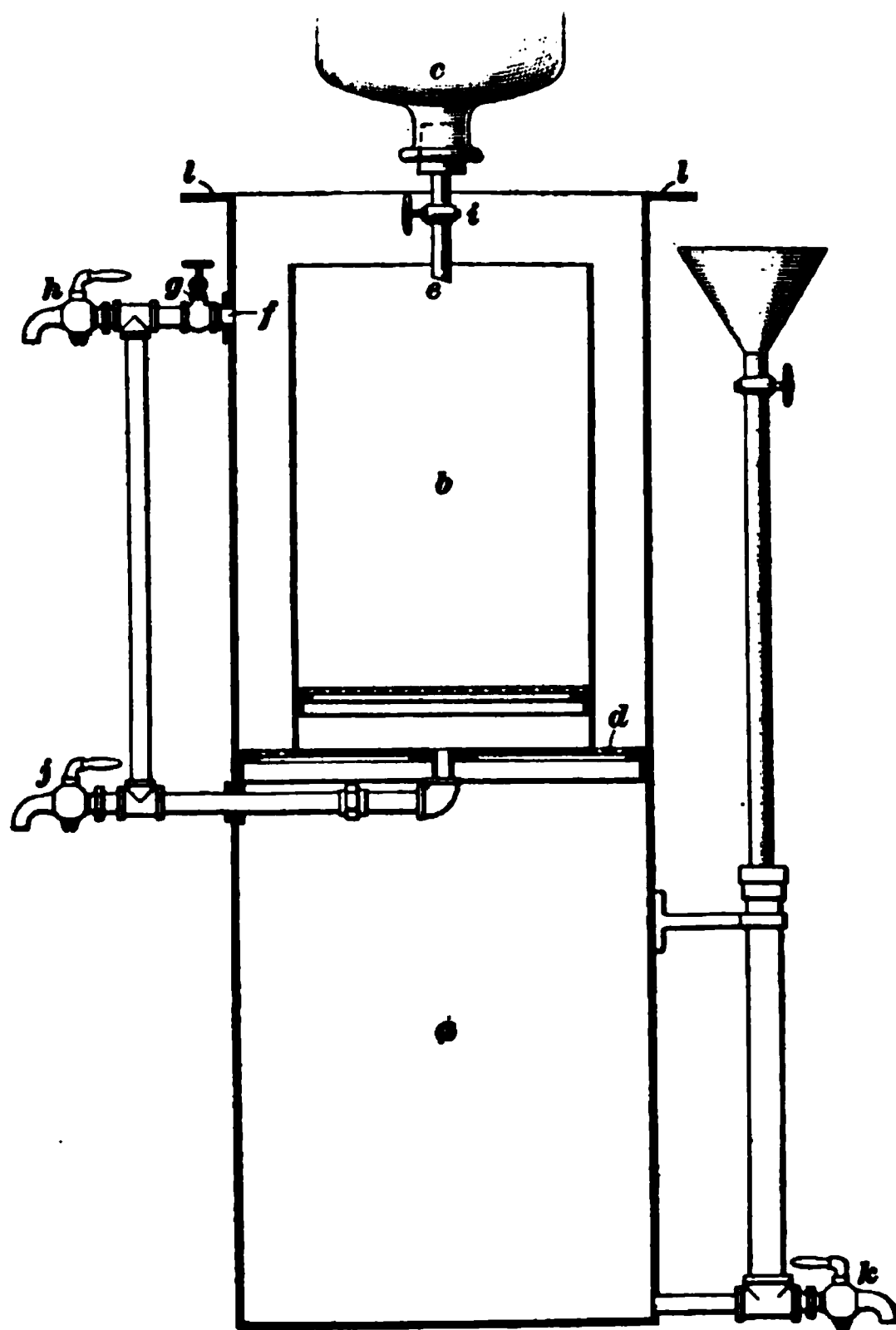


FIG. 17

**extractor**, which is shown in Fig. 17. By varying the method of operation, practically all tanning materials may be extracted by it. For use on sumac or like materials, which do not allow of an initial extracting temperature of boiling water, the material is weighed into a cup *b* that has a perforated brass bottom and rests on a perforated plate *d*



of the outer vessel *a*. Water is placed in the vessel *a* surrounding the cup *b* and is kept at the desired temperature by heat applied to the bottom of *a*. Suspended over cup *b* is an inverted vessel *c* filled with water and having an outlet *e* at a higher level than that of tube *f*. Cocks *g* and *h* are closed and cock *i* is opened, and water is allowed to flow into the cup. When the desired temperature is attained, cock *j* is partly opened and percolation begins, the extractives being delivered through cock *j* at any desired speed, additional water flowing from *c* as the level falls below the opening *e*. When the strong extractives have been removed, cock *j* is closed and some of the water surrounding *b* is drawn off through cock *h* until about 600 cubic centimeters of water remains in the bottom of *a*. The inverted vessel *c* is removed and to the flanges at *l* is attached a conical cap to the apex of which a condenser tube is brazed. An annular ring fitted to the interior surface of the cap serves to guide the water of condensation, so that it falls into the cup *b*.

The water in *a* is then boiled and the condensed steam falling into the cup *b* completes the extraction. The extractives may be delivered directly by closing cock *g* and opening either *h* or *j*. If continuous operation is desired, cocks *h* and *j* are closed and cock *g* is opened, and the extractive is returned to the lower part of *a*.

**76. The Teas Percolator.**—The Teas percolator extractor, shown in Fig. 18, may be used on all *new* materials, but a large volume of weak extractive solution results if used on *spent* or *leached* materials. It consists of small cylinders surrounded by a heating jacket *a*, the latter being supplied with water from a reservoir through *b*. The reservoir is located above the apparatus so that, when desired, the boiling point of the water may be raised above the normal boiling point. In operation, the perforated disks on the ends of brass rods *c* are covered with a thin layer of cotton or filter paper and the weighed material is brushed or washed into the cylinder and covered with water. Heat is applied to the bottom of the jacket, and when the desired

temperature is attained, the cocks *c* are opened and hot water allowed to drip on the material. The extracted material is delivered through any of the cocks *d*, depending on whether a flooding or a time percolation is desired. After the first portions of the extractives are removed, the heat is raised to the boiling point and the extraction completed.

**77. The Teas Cumulative Extractor.**—For all spent materials, as well as new materials, like oak and hemlock bark, etc., the Teas cumulative extractor, shown in Fig. 19, is more convenient than the percolative extractor described in the preceding article. The cumulative extractor may also be used on sumac and similar materials by varying the method of operation. In using this extractor, the stem *e* is connected to a copper or glass flask and the cap *d* to a condenser. The cock *f* and side openings *h* and *j* are closed. The material is weighed or washed in after cover-

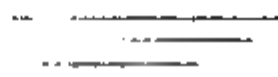


FIG. 19

ing the perforated plate at the bottom with a thin layer of cotton or filter paper, and then thoroughly moistened. A liter of water is placed in the flask, the apparatus connected up with the flask and the condenser, and heat applied to the bottom of the reservoir. The lower side opening *h* is opened, and the first portions of the extractives are collected there. After the strong extractives have been removed, the side opening is closed and the cock *f* opened, and a cumulative extraction continued until extraction is complete.

**78.** In extracting sumac and similar materials, which must have cooler initial extraction temperatures, the cap can be left off and water at the desired temperature allowed to drip on the material, collecting extractives at either side opening. When the strong portions have been removed, the cap is replaced, connected with the condenser, the side openings closed, the cock *f* opened, and the extraction completed with steam from the flask connected to the stem *e*. The materials mentioned may also be extracted by covering them with cold water almost to the level of the upper side opening, connecting with condenser and reservoir, boiling the water in the reservoir slowly, and collecting the first portions at the *upper* side opening *j*. When the desired amount of extractives is thus removed, the side opening is closed, the cock *f* opened, full heat applied to the reservoir, and extraction completed.

In all cases where strong extractives are removed from the apparatus, they should be mixed while hot with the weaker extractives that have accumulated in the reservoir, the entire extraction allowed to cool, made up to 1,000 cubic centimeters, and the analysis proceeded with.

**79. Remarks Regarding Determinations to Be Made.**—Three determinations, the *total solids*, *soluble solids*,

FIG. 19

and *non-tannins*, are made in a tannin analysis, and from the results the *insolubles*, or *reds*, and the *tannins* are obtained. The difference between the total-solids figure and the soluble-solids figure gives the amount of insolubles, or reds. By subtracting the non-tannin result from the soluble-solids results, the amount of tannins in the liquor is obtained.

These terms being self-explanatory, it is not necessary to dwell on the definition of each, but a few words on some of their constituents will not be amiss.

**80.** The reds, or insolubles, have been defined under tanning materials. Because of their greater or less solubility in warm liquor, it is necessary that the analysis should always be made when the liquor has a temperature of from 60° to 70° F. If colder, the reds figure will be higher and the subsequent tannin result lowered; if warmer, the reds will decrease and the tannin content increase.

Under non-tannins are classed all soluble substances in the liquor not absorbed by hide. For the most part the non-tannins consist of sugary substances derived from the sap of the tree. In the same manner, under tannins are included all soluble substances that will combine with hide, thus embracing all the forms of tannic acid.

**81. Determination of Total Solids.**—When the liquor, extracted and prepared as has been described, has cooled to 20° C., the cylinder *a*, Fig. 19, is shaken and then allowed to stand for  $\frac{1}{2}$  hour; this is to allow small particles of bark to settle, so that they will not be counted as reds, or insolubles proper. At the expiration of  $\frac{1}{2}$  hour, remove with a pipette 100 cubic centimeters of the liquor, place in a weighed glass crystallizing dish, and evaporate to dryness in a combined evaporator and dryer. Cool in a desiccator and weigh. From this weight the percentage of total solids is determined.

**82. Determination of Soluble Solids.**—To determine the soluble solids, place 1 gram of kaolin in a beaker and add 75 cubic centimeters of the tannin solution. Stir and pour on a pleated filter paper, collecting the filtrate in a clean beaker. Then return the filtrate to the paper for 1 hour, keeping the filter full. At the expiration of 1 hour, remove any of the solution remaining in the funnel and throw away both it and the filtrate. Refill the filter with the tannin solution, and as soon as the filtrate runs clear, collect it in a clean, dry beaker

and remove 100 cubic centimeters for evaporation and drying. The kaolin should be previously washed with hydrochloric acid, then with distilled water, and finally dried and pulverized. It is used as an aid in filtering, forming a thin film over the paper, thus insuring a clear filtrate. The paper and kaolin absorb tannin from the solution, so that the affinity of these for tannin must be satisfied by allowing them to be in contact with the tannin solution for 1 hour before filtering the solution to be collected for drying and weighing.

**83. Preparation of Hide Powder for Determining Non-Tannins.**—To determine the non-tannins, hide powder is used. Hide powder is made by liming and depilating selected steer hides, neutralizing the lime remaining in the hide, and washing out the excess of acid with water. The hide is then slowly and carefully dried without heat, and when dry it is ground about as fine as sawdust.

To prepare hide powder for use, the almost universal practice is to chrome it slightly. The chroming treatment increases the rapidity of absorption of the tannins, and by combining with the chrome-tanning materials the soluble portions of the hide substance are rendered insoluble. The American method of chroming is first to soak the dry hide powder overnight in water and then squeeze out the soak water through a linen cloth. Fresh water approximating twenty-five times the weight of the dry hide powder is then added, and chrome alum (in solution) to the amount of 3 per cent. of the weight of the dry hide powder is then added and thoroughly mixed. The mixture is frequently stirred during the day, allowed to stand overnight, and washed the next morning by alternately squeezing through a cloth and adding fresh water until the wash water is free from sulphates. When thoroughly washed, the mass is placed in a press and squeezed until the wet hide contains between 70 and 75 per cent. of water. It is then ready for use for detannizing the tannin solutions.

**84. Determination of Non-Tannins.**—For the non-tannin determination, measure 200 cubic centimeters of the

bark liquor into a strong glass tumbler, such as is used with a milk-shake machine, and after weighing 20 grams of the wet hide, to be placed in the steam oven and dried for moisture determination, weigh out from the press the amount of wet hide necessary for the determination of non-tannins. Place this in the liquor, breaking up the lumps with a glass rod, and then thoroughly shake. The shaking may be done by hand, using a tin cap, such as is used for mixing drinks, or by a hand- or power-driven milk-shake machine. Shaking for 5 minutes on a milk shaker is sufficient for the hide powder to absorb every trace of tannin from the liquor. After shaking, add about 2 grams of kaolin and filter through double filter paper. When the filtrate is running clear, collect, and with a pipette remove 100 cubic centimeters to a crystallizing dish; evaporate, dry, and weigh, as under the solids determination.

The amount of hide powder to be used depends on the strength of the bark liquor. In the case of unleached materials, the amount of sample extracted and the proportion of extraction water should be such as to give between .35 and .45 gram of tannin per 100 cubic centimeters of extractive solution. If these specifications have been carried out, an amount of wet hide powder representing from 12 to 15 grams of the dry powder should be used for 200 cubic centimeters of the solution. In extracting spent materials, it is seldom found possible to procure an extractive solution that will contain .35 to .45 gram of tannin per 100 cubic centimeters, but the proportion should be approximated as closely as possible, and the quantity of hide powder used should be decreased accordingly.

Whether or not enough hide powder has been used can generally be judged by the appearance of the non-tannin filtrate; if clear and white or pale yellow, the tannin has probably been removed. If the filtrate has a red or brown tinge, it is generally safe to assume the presence of some tannin. Doubtful filtrates should be tested with a 1-per-cent. gelatine to 10-per-cent. salt solution, a cloudiness indicating the presence of tannin.

**85. Calculation of Results of Bark Analysis.** Divide the weight of the total-solids residue by the number of grams of bark taken, and divide this result by the percentage of actual bark in the sample, found by subtracting from 100 the percentage of moisture, as determined in a 10-gram moisture sample. This result, when pointed off to correspond to the decimal part of the original liter, is the percentage of total solids. The percentage of total soluble solids is found in the same manner.

Because of the water added by the wet hide used in the non-tannin determination, a correction must be made. If the 20-gram sample of wet hide powder when dry weighs only 6 grams, there are 14 grams of water added to the liquor for every 20 grams of wet hide used. If 40 grams of wet hide is used, there are 28 grams of water added, and the volume then becomes 228 cubic centimeters instead of the 200 cubic centimeters originally taken; 100 cubic centimeters of the thus diluted filtrate has been dried, and it accordingly represents only  $\frac{100}{228}$  of the actual amount of non-tannins, so the weight must be multiplied in this case by 1.14. Therefore, to calculate the percentage of non-tannins, divide the non-tannin weight successively by the number of grams of bark taken and the percentage of dry bark, as under the solids calculations, and multiply this result by the hide-moisture correction.

**ILLUSTRATION.**—For the analysis, 25 grams of bark were taken and 40 grams of wet hide powder were used. The bark contained 12 per cent. of moisture and 88 per cent. of dry bark. A 20-gram sample of wet hide when dried weighed 7 grams. The 40 grams of hide used therefore contained 14 grams of dry hide and 26 grams, or cubic centimeters, of water, which latter was added to the original 200 cubic centimeters.

$$\frac{200 + 26}{200} = 1.13, \text{ or the hide-powder correction for moisture}$$

	GRAM
Total-solids residue weighed . . . . .	.4983
Total soluble-solids residue weighed . . . . .	.4012
Non-tannin residue weighed . . . . .	.1441

For the total-solids determination, 100 cubic centimeters of liquor was taken, or .1 of the liter. The calculation would be as follows:

$$\frac{.4983 \times 100 \times 10}{25 \times .88} = 22.65 \text{ per cent. of total solids}$$

The total soluble solids are calculated in the same manner.

$$\frac{.4012 \times 100 \times 10}{25 \times .88} = 18.24 \text{ per cent. of total soluble solids}$$

The total solids less the total soluble solids give the amount of insolubles.

$$22.65 - 18.24 = 4.41 \text{ per cent. of insolubles}$$

For the determination of non-tannins, 100 cubic centimeters, or  $\frac{1}{10}$  liter of liquor, was dried. The hide-powder correction was found to be 1.13. The calculation would be as follows:

$$\frac{.1441 \times 100 \times 10 \times 1.13}{25 \times .88} = 7.40 \text{ per cent. of non-tannins}$$

The total soluble solids less the non-tannins give the amount of available tannin.

$$18.24 - 7.40 = 10.84 \text{ per cent. of available tannin}$$

The complete analysis is as follows:

	PER CENT.
Total solids { Total soluble solids { Non-tannins . . . 7.40 Tannins . . . . . 10.84 } 18.24 Reds, or insolubles . . . . . 4.41 }	22.65
Insoluble parts of bark (not removed by leaching) . . . . .	77.35
Total . . . . .	100.00

This would be reported as follows:

	PER CENT.
Moisture . . . . .	12.00
Total solids . . . . .	22.65
Soluble solids . . . . .	18.24
Non-tannins . . . . .	7.40
Tannins . . . . .	10.84
Reds (or insolubles) . . . . .	4.41

86. The figures in the preceding illustration are, of course, on an absolutely dry basis. If it were desired to report the results on the commercially dry basis, simply multiplying the absolutely dry figures by .88 would give the commercially dry figures. The sample having contained 12 per cent. of moisture, there would, of course, be 88 pounds of absolutely dry bark in every 100 pounds of the commercial article.



It is customary to report fresh-bark results on the absolutely dry basis, and then give the tannin figure also on the commercially dry basis. Spent-material results should be reported on the dry basis and cannot really be reported on the commercial basis unless the analysis of the original new material is known. This is because a considerable portion of a new bark is removed by the leaching process, and the analysis of the spent bark is not on the same basis as to bark weight as was the analysis of the original new bark. Taking this into account and figuring back the results to the same basis, the commercially dry tannin figure of a spent tan analysis is found to be about 77 per cent. of absolutely dry tannin figure.

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#### ANALYSIS OF TANNING EXTRACTS

**87.** The exact conditions to which an extract analysis must conform, in order that it may be said to have been made by the "Official Method," given later, are set forth annually in the report of the American Leather Chemists' Association, which society comprises practically all the leather chemists of the United States. As now carried out, the method is to dissolve such quantity of the extract as will give from .35 to .45 gram of tannin per 100 cubic centimeters of solution in 900 cubic centimeters of water at 80° C., making up to the liter mark after standing not more than 20 hours and not less than 12 hours. The temperature of the solution must not go below 20° C.

**88. Total Solids.**—Thoroughly mix the solution, and pipette 100 cubic centimeters into a tared glass dish. Evaporate, dry, and weigh.

**89. Soluble Solids.**—Place 1 gram of acid-washed kaolin in a beaker and add 75 cubic centimeters of the solution. Stir and pour on a No. 590 S. & S., 15 centimeters, pleated filter paper. Return the filtrate to the paper for 1 hour, keeping the filter full. At the expiration of 1 hour, pour the remaining solution from the filter or remove with a pipette. Then refill the filter with another portion of the

solution brought to a temperature of 20° C., and begin to collect the filtrate as soon as filtrate runs clear. Pipette 100 cubic centimeters of the clear filtrate into a tared glass dish, and evaporate, dry, and weigh. The funnels and receiving vessels should be kept covered to guard against evaporation.

**90. Non-Tannins.**—Add to 200 cubic centimeters of the solution a quantity of wet hide powder representing from 12 to 15 grams of dry hide. Shake for 10 minutes and squeeze immediately through a linen cloth. Add 2 grams of kaolin to the filtrate, stir, and filter through a folded filter of size sufficient to hold entire filtrate, returning the filtrate until it is running clear. Evaporate and dry 100 cubic centimeters of this filtrate. The hide powder is to be prepared as previously described, and the non-tannin filtrate should be tested for tannin if its presence is suspected.

**91. Calculation of Results of Tanning-Extract Analysis.**—The results are calculated by dividing the different weights by the amount of extract taken and pointing off for the percentage basis, not forgetting the hide-moisture correction on the non-tannin weight.

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### ANALYSIS OF TAN LIQUOR

**92. Determination of Specific Gravity and Total Solids.**—Shake the sample well and with a barkometer determine its specific gravity in degrees barkometer. As a general rule, 1° barkometer represents .25 per cent. of total solids, and by applying this rule, the amount of liquor to be taken to make the proper dilution for analysis may readily be computed. The liquors should be diluted so that 100 cubic centimeters of the diluted liquor will give a residue approximating .7 gram in weight. The water used for dilution should be at a temperature of 70° F. After thoroughly mixing the diluted liquor, the total solids, soluble solids, and non-tannins are determined as under Analysis of Tanning Extracts. Since the dilution varies with the grav-

ity of the liquor, the tannin strength of the different diluted liquors is not the same, and different amounts of hide powder are used, depending on the tannin content of the liquor.

Table I shows what is believed to be the proper amounts of hide powder to be used for different tannin strengths.

**TABLE I**  
**AMOUNT OF HIDE POWDER REQUIRED FOR DIFFERENT**  
**TANNIN STRENGTHS**

Tannin Range per 100 Cubic Centimeters	Dry Hide Powder per 200 Cubic Centimeters
.35 to .45 gram	8 to 10 grams
.25 to .35 gram	5 to 8 grams
.15 to .25 gram	2 to 5 grams
.00 to .15 gram	0 to 2 grams

For convenience in calculating results, it is best to dilute the liquors to the volume of 1 liter. When thus diluted, the weights of the different residues divided by the number of cubic centimeters of liquor diluted to 1 liter will give a result that only needs proper decimal pointing to indicate the percentage of each item. The moisture correction for the hide powder must be applied to the non-tannin weight.

**93. Determination of Total Free Acids.**—There are several methods in use for the determination of the total free acids, but none is above criticism and results are comparative rather than absolute.

*Charcoal Method.*—To 100 cubic centimeters of the diluted liquor used for the determination of the tannin, add 2 grams of chemically pure animal charcoal. Stir frequently during a period of 2 hours, filter on a dry filter, and titrate an aliquot portion with decinormal alkali, using phenol-phthalein indicator.

Or, to 100 cubic centimeters of the diluted liquor in a flask with a tube condenser add 2 grams of the charcoal. Heat to boiling with frequent shaking; then cool, filter, and titrate an aliquot portion.

*Quinine Method.*—Dilute 50 cubic centimeters of original liquor to 500 cubic centimeters. To 200 cubic centimeters of the diluted liquor, add 20 cubic centimeters of quinine solution. Mix thoroughly and filter. Take 100 cubic centimeters of the filtrate and titrate with decinormal alkali and phenol-phthalein indicator. Multiply the number of cubic centimeters used by .066 to obtain direct the percentage of acid, as acetic acid, in the original liquor.

The quinine solution is made by dissolving 15 grams of quinine (pure alkaloid) in 110 cubic centimeters of 95-per-cent. alcohol that has previously been neutralized. To this add slowly while stirring 90 cubic centimeters of distilled water, so as to make the volume to 200 cubic centimeters.

*Lime-Water Method.*—Titrate 20 cubic centimeters of the original liquor, filtered, with twentieth normal lime water. The end point is indicated by the beginning of turbidity, when sufficient lime water has been added. Some chemists put the filtered liquor in a flat 2-ounce "panel" bottle, in which the panels are very close, and then titrate, holding the bottle against a strong light.

**94. Determination of Combined Sulphuric Acid.** In acid tanneries, a determination of the free and combined sulphuric acid present in the liquors is frequently required. To determine the *combined sulphuric acid*, evaporate 100 cubic centimeters of the original liquor in a platinum dish and char the residue at a very low red heat. Cool, add hydrochloric acid and hot water, filter, and determine the sulphates in the filtrate with barium chloride, as explained in *Quantitative Analysis*.

To determine the *total sulphuric acid*, take 50 cubic centimeters of the original liquor, add distilled water and a little hydrochloric acid, bring to a boil, and precipitate the sulphuric acid with barium chloride. The difference between the percentages of total acid and combined acid will be the approximate *free sulphuric acid* in the liquor.

When the amount of free sulphuric acid only is required, a more accurate method is to evaporate 100 cubic centimeters

of the liquor on a steam bath and digest the residue with absolute alcohol, determining sulphuric acid in the alcohol after digestion.

**95. Bleach Liquors.**—It is frequently desirable to know the amount of material removed from leather by the "bleach" baths. The following method gives fairly accurate figures:

Take samples of all baths before starting the day's work and at the close of the day. Evaporate and dry 50 cubic centimeters of each sample, weigh, and subtract the combined "morning" percentages from the combined "evening" percentages. Multiply the difference in percentages by the weight of water in a single vat, and from the result subtract the weights of soda and acid added during the day (acid weights should be taken at 100 per cent. and sal soda weights at 40 per cent. actual solids). The remainder will be the approximate amount of organic material removed in all the vats. When this figure is divided by the number of sides bleached, the amount of solids removed from each side of leather will be obtained.

A method of determining the amount of tanning material removed by the soda vat is to evaporate and dry 50 cubic centimeters of the liquor in a platinum dish, weigh, and then char the contents, break up the charred mass, add hot water and titrate. The difference between the weight of the dried residue and the weight of the alkali (figured in its form at the drying temperature), will give the organic matter in 50 cubic centimeters, and knowing the size of the vat and the number of sides bleached, the amount removed per side may be readily calculated.

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#### ANALYSIS OF LEATHER

**96.** For many reasons, it is frequently desired to determine quantitatively the constituents of different leathers, and while the analysis of leather is not difficult, yet, in order that different analysts may secure concordant results, it is necessary for them to follow identical methods in determining the composition of leather.

The samples should be taken from different parts of the side of leather, since different portions of the leather will show a difference in composition, because of the difference in the thickness and texture of the hide. The belly and flank, being softer than the back, will make leather showing an entirely different composition from that of samples taken from the back of the same side of leather.

The samples are prepared by grinding, or by shaving with a carpenter's plane, or by the use of a coarse wood rasp. The finely divided leather should be well mixed and stored in a stoppered glass jar.

**97. Determination of Moisture.**—In determining the amount of moisture present, 10 grams of the ground leather should be dried for 1 hour in an oven at a temperature of 105° C. This period of time will generally suffice to drive off moisture from most samples, but occasional samples require a longer time. Thus, after taking the dry weight it is well to replace the sample in the oven and subject it to a further drying of 15 minutes, weighing it again in order to verify the dry weight originally obtained.

**98. Determination of Ash.**—For the determination of ash, 15 grams of the ground leather should be burned in a platinum dish. The leather should be slowly heated until all volatile matter is driven off; then the charred mass may be broken up and the ignition concluded.

Mineral adulterations will be indicated by the analysis of the ash, and these are determined by a quantitative examination of the residue. Epsom salts are quite commonly used for brightening and tempering leather and also for adulteration, and if this material is the only constituent of the ash to be sought, its presence may be quickly determined by dissolving the ash in hydrochloric acid, precipitating iron and alumina with ammonia, and filtering. After precipitating and filtering off the lime, the magnesium is determined in the cooled filtrate by precipitation with sodium-ammonium phosphate.

**99. Determination of Oil.**—To determine the oil and grease in leather, a 15-gram sample is extracted in a glass Soxhlet extractor for 3 hours, using about 100 cubic centimeters of petroleum ether as a solvent. The petroleum ether should be tested by evaporating 100 cubic centimeters in a tared dish and weighing any residue. The oil extraction should be conducted by heating the flask on a steam bath, so that there shall be a constant ebullition of the petroleum ether and a steady drip of the condensed vapor falling on the leather in the Soxhlet apparatus. When extraction is complete, pour the ether (which should now contain the oil and grease originally in the leather) into a tared, glass crystallizing dish, rinsing out the flask with a little additional petroleum ether. After evaporating off the ether, the oil residue remaining in the crystallizing dish is dried and weighed. To determine the nature of the oils or greases used, a larger quantity of the leather must be extracted in order that the oil residue may be sufficiently large to admit of qualitative and quantitative examination.

**100. Determination of Nitrogen.**—The amount of hide substance in a leather is found by first determining the percentage of nitrogen in the sample. From this figure the percentage of hide contained in the leather is calculated by dividing by the factor .178. This factor is generally agreed on as the result of many analyses, which showed the average nitrogen content of hide substance to be 17.8 per cent.

To determine nitrogen in leather, the oil in the leather must first be extracted, as the presence of fatty oils or greases would, of course, give a fictitious nitrogen result. It is convenient to dry the residue from the sample used for determining the oil, making the nitrogen determination on this dried, oil-free sample. The method is practically the well-known Kjeldahl nitrogen method, some slight modifications being made in its operation. Of the dry, oil-free sample 1.5 grams is weighed into a Kjeldahl flask, and 20 cubic centimeters of strong sulphuric acid and 1 drop of metallic mercury added; the mercury is added to help in the oxidation

of the carbonaceous matter. A loose-fitting, hollow balloon stopper is placed in the neck of the flask, and the flask is then held in a sloping position over a low flame that is gradually increased, and the contents are allowed to boil slowly until nearly colorless. While still hot, drop in crystals of potassium permanganate until the solution remains slightly purple. Then transfer it to a distilling flask with 300 cubic centimeters of water, add 25 cubic centimeters of potassium-sulphide solution (40 grams to liter), and connect the flask with the water condenser, being careful to have all joints absolutely tight.

The distilling flask should be provided with a double-perforated stopper, one perforation for the tube leading to the condenser, and the other for the stem of a separatory funnel. After passing through the water-jacket, the delivery tube should be connected by means of a tight-fitting, perforated cork to one leg of a large, bulbed U tube containing 50 cubic centimeters of  $\frac{n}{1}$  sulphuric acid. The U tube is set in a larger beaker about half full of cold, neutral, distilled water. After connecting the distilling apparatus, a strong solution of sodium hydroxide is placed in the separatory funnel, and by gradually opening the cock, an excess of the solution is run into the flask and the cock then closed. Heat is then applied to the flask and slow distillation continued for about 30 minutes. The ammonia released by the addition of the alkali passes over through the condenser and is absorbed by the  $\frac{n}{1}$  acid in the U tube. When the distillation is complete, the acid in the U tube is titrated back to neutrality with  $\frac{n}{1}$  ammonia, using cochineal as an indicator. The water in which the U tube has been immersed should always be titrated in case the U tube has overflowed. The amount of standard ammonia used in the titration, deducted from 50 cubic centimeters, gives the quantity of acid neutralized by the ammonia from the leather, each cubic centimeter of which corresponds to .017 gram of ammonia,



or .014 gram of nitrogen. The percentage of nitrogen divided by .178 gives the percentage of hide fiber in the leather.

The reagents used must be free from ammonia, and a blank test, using sugar, should be made, making correction, if necessary, on subsequent determinations of nitrogen in leather.

**101. Determination of Water-Soluble Materials.** The estimation of the amount of water-soluble materials in leather presents only mechanical difficulties encountered in the extraction of the leather. The total amount varies with the period of extraction, although after a certain time the remaining solubles are not appreciable. The ground leather may be extracted by simple digestion with successive quantities of water at 40° to 50° C., squeezing the mass in a linen cloth after each digestion and then adding fresh water. This kind of extraction results in a large volume of weak extractive solution, which is sometimes concentrated by boiling, so that the entire volume is reduced to 1 liter. If only the total amount of water solubles is desired, this procedure is not objectionable; but when the constituents of the water-soluble matters are to be determined, concentration by boiling should be avoided. Probably the best method of extraction is to digest the sample three or four times with water at from 40° to 50° C., then transfer the mass of leather to a glass Soxhlet, and complete the extraction, uniting the extractives secured by the two methods. The boiling temperature necessitated by the Soxhlet extraction will cause the leather to run together and form a sticky mass, through which the extracting water can pass only with difficulty. This may be prevented to some degree by mixing the leather with several times its volume of sand before placing it in the extractor. For the water-soluble determination, 20 grams of the sample should be extracted, as just outlined, and the extractive solution brought to a liter in volume. This is then analyzed for tannins and non-tannins, according to the methods for tan-liquor analysis previously described.

**102. Determination of Glucose.**—Glucose in leather is determined in the water-soluble material by Fehling's solution after removing the tannin. The tannin is removed by basic lead-acetate solution, which is made as follows: 300 grams of lead acetate is mixed with 100 grams of litharge and 50 cubic centimeters of water in a liter flask. The flask is then heated on a boiling-water bath until the mixture is nearly white, more water being put in the flask to replace that which evaporates. The mixture is then digested with 1 liter of cold water and then filtered.

The lead-acetate solution having been made, 20 grams of the leather is digested with successive small portions of water, filtering after each digestion through a cotton plug stuck in the neck of a funnel. The temperature of the extracting water should be gradually increased from 40° C. for the first digestion to boiling water for the last two digestions. The extractive solution should amount to 500 cubic centimeters, and after cooling, 30 cubic centimeters (or more) of the basic lead-acetate solution is added, well mixed by shaking, allowed to stand for 15 minutes, and then filtered through a dry filter, collecting exactly 400 cubic centimeters. To the 400 cubic centimeters of filtrate add 30 cubic centimeters (or more if necessary to throw out the lead) of a strong magnesium-sulphate solution, shake, and filter on a dry filter. Boil 100 cubic centimeters of this filtrate with 3 cubic centimeters of strong hydrochloric acid for 3 hours, not allowing the volume to go below 75 cubic centimeters. This is for the purpose of inverting unconverted dextrin and intermediate products, which are generally present in commercial glucose and which, unless inverted, are not determined by Fehling's solution.

After boiling, make the solution slightly alkaline by the addition of concentrated sodium-hydroxide solution; make up to 100 cubic centimeters and filter if necessary. Transfer the solution to a clean burette and use it to titrate 10 cubic centimeters of Fehling's solution. For this operation 5 cubic centimeters of each of the Fehling solutions are placed in a casserole, 40 cubic centimeters of water added, and the

whole brought to a boil. Run in from 5 to 10 cubic centimeters of the sugar solution at a time, boiling the liquid 2 minutes between each addition, until the blue color has nearly disappeared. The sugar solution should then be added in smaller quantities and the time of boiling reduced to  $\frac{1}{2}$  minute between each addition from the burette. The end point may be determined by the absence of blue color on looking through the supernatant liquor, or potassium ferrocyanide may be used as an indicator. If the indicator is used, take a few cubic centimeters of the solution, filter through a very small filter, and add a little acetic acid and 1 drop of potassium-ferrocyanide solution.

**103.** It is well to make an approximate titration at first and then a second titration on another 10 cubic centimeters of Fehling's solution, adding nearly the whole of the required sugar solution at once, so that the time of boiling and titration is reduced to a minimum. Fehling's solution, of which 10 cubic centimeters equals .05 gram of glucose, is made in two parts as follows:

In making solution 1, 34.6 grams of pure crystallized copper sulphate is dissolved in distilled water, 10 cubic centimeters normal sulphuric acid added, and the whole made up to 500 cubic centimeters.

In making solution 2, 125 grams of chemically pure potassium hydrate and 173 grams of pure potassium sodium tartrate (Rochelle salts) are dissolved in distilled water and made up to 500 cubic centimeters.

To make Fehling's solution, 5 cubic centimeters of each of these solutions are mixed just before using.

A convenient strength of the magnesium-sulphate solution is made by titrating 10 cubic centimeters of the basic lead-acetate solution with a strong solution of magnesium sulphate until no further precipitate is produced. One hundred times the quantity of sulphate solution needed for the titration is made up to a liter, and the use of this solution will result in the removal of the lead without a large residual excess of magnesium sulphate.

**OFFICIAL METHOD OF THE A. L. C. A. FOR  
TANNIN ANALYSIS**

**104.** The following methods have been recommended and adopted by the American Leather Chemists' Association:

**CRUDE MATERIALS**

1. *Moisture Determination.*—Upon the receipt of the sample, grind promptly and dry 10 grams in the manner and for the period specified for evaporation and drying in Extract Analysis.

2. *Preparation of Sample for Extractions.*—Sample must be dried at a temperature not exceeding 60° C., and then ground to such a degree of fineness that the entire sample will pass through a sieve of 20 meshes to the inch (linear).

3. *Amount of Sample and Proportion of Water for Extraction.* For fresh materials, the amount of sample and proportion of water for extraction should be such as to give between .35 and .45 gram tannin per 100 cubic centimeters of solution. For spent materials, this proportion should be approximated as closely as practicable.

4. *Extraction of Sample.*—Extraction shall be conducted in a form of apparatus that permits the removal of the extractive solution from the influence of sustained high temperature, and shall be continued till a portion tested with gelatine-salt solution fails to give a precipitate. At least 400 cubic centimeters of the first portions of extractive solution should be removed and not subjected to further heating. A thin layer of cotton must be used in order to prevent fine material passing over.

5. *Analysis.*—After extraction and dilution, solutions must be heated to 80° C., and analysis conducted as per official method for extracts. In case of weaker dilutions than the official method specifies, the amount of hide powder must be reduced in proportion to the reduction of tannin.

Ten grams of the air-dried sample should be dried as in method 2, to determine moisture content of the portion extracted, and the analysis calculated and reported upon a "dry" basis. The tannin in fresh materials should also be reported on the basis of the moisture content of the sample "as received."

**ANALYSIS OF EXTRACTS**

6. *Amount and Dilution for Analysis.*—Fluid extracts must be allowed to come to room temperature and weighed in stoppered weighing bottle. Such quantity shall be taken as will give from .35 to .45 gram tannin per 100 cubic centimeters of solution; dissolve in exactly 900 cubic centimeters of distilled water at 80° C., and make up to mark after standing not more than 20 hours nor less than 12 hours. Temperature must not go below 20° C.

7. *Total Solids*.—Thoroughly mix solution, pipette 100 cubic centimeters into tared dish, evaporate and dry as directed under Evaporation and Drying.

8. *Soluble Solids*.—To 1 gram of kaolin in a beaker add 75 cubic centimeters of solution; stir and pour on 590 S. & S. 15-cubic-centimeter pleated filter paper; return filtrate to paper for 1 hour, keeping filter full. At end of hour pour solution from filter or remove with pipette. Bring 800 cubic centimeters of solution to 20° C.; refill the filter with this solution and begin to collect filtrate for evaporating and drying so soon as filtrate comes *clear*. Keep filter full. Evaporate and dry the first 100 cubic centimeters of filtrate, as per Evaporation and Drying. Funnels and receiving vessels must be kept covered during collection of filtrate for evaporation.

9. *Non-Tannins*.—A quantity of hide powder sufficient for the number of analyses to be made shall be prepared in the following manner: Digest with twenty-five times its weight of water till thoroughly soaked. Add 3 per cent. of chrome alum in solution. Agitate by either shaking or stirring occasionally for several hours and let stand overnight. Wash by squeezing through linen, continuing the washing until the wash water gives no precipitate with barium chloride. Squeeze the hide, using a press, if necessary, so that the wet hide will contain between 70 and 75 per cent. of water. Use approximately 20 grams of wet hide for moisture determination. Add to 200 cubic centimeters of the original solution such quantity of the wet hide as represents from 12 to 15 grams dry hide. Shake for 10 minutes in some form of mechanical shaker and squeeze immediately through linen. Add 2 grams kaolin to the filtrate, stir and filter through folded filter (No. 1 F Swedish recommended) of size sufficient to hold entire filtrate, returning till clear. Evaporate 100 cubic centimeters of the filtrate. The weight of the residue must be corrected for the dilution caused by the water contained in the wet hide powder.

The non-tannin filtrate must not give a precipitate with a 1-per-cent. gelatine 10-per-cent. salt solution.

10. *Tannin*.—The tannin content is shown by the difference between the soluble solids and the corrected non-tannin.

#### ANALYSIS OF LIQUORS

11. *Dilution*.—Liquors must be diluted for analysis so as to give as nearly as possible .7 gram solids per 100 cubic centimeters of solution.

12. *Total Solids*.—To be determined as in Analysis of Extracts.

13. *Soluble Solids*.—To be determined as in Analysis of Extracts.

14. *Non-Tannins*.—To be determined by shaking 200 cubic centimeters of solution with an amount of wet chromed hide powder, containing 70 per cent. to 75 per cent. moisture, corresponding to an amount of dry hide powder shown in the following table:

TANNIN RANGE PER 100 CUBIC  
CENTIMETERS

GRAM  
.35 to .45  
.25 to .35  
.15 to .25  
.00 to .15

DRY HIDE POWDER PER  
200 CUBIC CENTIMETERS

GRAMS  
8 to 10  
5 to 8  
2 to 5  
0 to 2

Solutions to be shaken for non-tannins as in Analysis of Extracts; 100 cubic centimeters must be evaporated as in Analysis of Extracts.

EVAPORATION AND DRYING

15. *Evaporation and Temperature.*—All evaporations and dryings shall be conducted in the form of apparatus known as the Combined Evaporator and Dryer, at a temperature not less than 98° C. The time for evaporation and drying shall be 16 hours.

16. *Dishes.*—The dishes used for evaporation and drying of all residues shall be flat-bottom glass dishes not less than 2 $\frac{3}{4}$  inches in diameter nor greater than 3 inches in diameter.

DETERMINATION OF TOTAL ACIDITY OF LIQUORS

17. *Place 100 Cubic Centimeters of the Liquor in a 500-Cubic Centimeter Flask and Make Up to the Mark With Water.*—To 100 cubic centimeters of diluted liquor in a flask with tube condenser add 2 grams of chemically pure animal charcoal. Heat to boiling temperature with frequent shaking, cool, filter, and titrate an aliquot portion with decinormal alkali.

PROVISIONAL METHODS FOR SAMPLING TANNING  
MATERIALS

1. *Liquid Extract in Barrels.*—Samples to be taken at a temperature of 40° F. minimum from 10 per cent. of the packages, as near as possible, by means of sampling tube, which shall enter the bung and extend to at least the center of the barrel. These samples to be thoroughly mixed, using due precaution to prevent evaporation, and a composite sample of at least 4 ounces, in duplicate, removed, sealed, and labeled, with date of sampling, name of material, invoice, number, or other means of identification.

2. *Liquid Extract in Bulk.*—Extract shall be thoroughly plunged and sampled by passing a sampling tube to the bottom, through at least five sectors of contents, samples to be mixed thoroughly and composite samples drawn, sealed, and labeled, as in Liquid Extract in Barrels.

3. *Liquid Extract in Tank Cars.*—(a) Where tank car extract is unloaded, without the use of direct steam, into an empty container, the method of sampling is to be the same as for Liquid Extract in Bulk, the sample being taken from the container after the car is

unloaded. (b) Tank cars unloaded without the use of direct steam shall be sampled by taking at least five pint samples of the extract as it flows from the car. One of these samples to be taken about 3 minutes after starting to unload, one to be taken about 3 minutes before unloading is completed, and the other three samples to be taken at equal intervals between the first and last. These samples to be mixed and composite samples taken, sealed, and labeled as usual. Or, in case direct steam is used in unloading a tank car, shipment may be sampled according to the methods of sampling the liquid extract in bulk, the samples being taken directly from the car.

4. *Solid Extracts*.—Solid extracts shall be sampled by taking a section from the center of the package to the surface after the removal of the cover. Samples as taken shall be immediately placed in clean, dry, closed receptacles, and when sampling is completed, broken, thoroughly mixed, and duplicate samples of at least 6 ounces placed in a clean, dry, glass receptacle, sealed, and properly labeled. Sampling at place of manufacture shall be conducted by running portion from middle of strike into a mold holding at least 2 pounds and, immediately after cooling, selecting samples for analysis by method given above.

On lots of 300 bags or 100 barrels, at least 5 per cent. of the bags or barrels shall be selected for sampling. On lots of 301 to 2,000 bags or 101 to 700 barrels, 3 per cent. shall be sampled. On lots of more than 2,001 bags or 701 barrels, 1 per cent. shall be sampled.

When a considerable period of time elapses between the sampling and analysis of sample, the latter should be weighed on day of sampling, and certified weight should appear on label.

5. *Crude Tanning Materials*.—Shipments in bags, mats, or barrels, of barks, nuts, beans, fruits, leaves (ground and unground), roots, and ground wood, are to be sampled by opening each of the packages chosen for sampling and selecting an equal portion therefrom. These samples to be mixed and composite samples of the required amount taken and labeled as usual. In lots of 20 tons or less, 5 per cent. of the packages shall be sampled. In lots of above 21 tons to 100 tons, 3 per cent. shall be sampled. In lots of above 101 tons, 1 per cent. of the packages shall be selected for sampling.

6. *Crude Tanning Materials in Bulk*.—(a) *Barks, Nuts, Beans, Pods, Ground Materials, Etc.* Equal portions shall be selected from at least five parts of the lot, mixed, sealed, and labeled in duplicate.

(b) *Wood*.—Billets or logs shall be selected from at least five parts of the lot and the sawdust obtained by sawing completely through each billet, or log, selected, thoroughly mixed, sealed, and labeled in duplicate.

7. *Sampling of Spent Tan and Spent Wood*.—Spent tan and wood samples should be taken from the top, middle, and bottom of a spent

leach and placed in a covered pail, contents of pail to be stored in a covered barrel to be kept for the desired period. When laboratory sample is desired, thoroughly mix contents of the barrel and dry a portion over steam pipes in a location free from bark dust. The dry laboratory samples should be at least 10 ounces.

8. *Ground Barks and Cut Wood*.—These samples should be taken at intervals as the ground material enters the leach. Composite samples shall be made up from these samples and shall be submitted undried to the laboratory.

FIG. 20

9. *Liquor Samples*.—Routine samples shall be taken by plunging the liquor and removing a pint and storing in earthenware crocks having earthenware lids. The samples should be of the same size and taken under exactly similar conditions. The storage of crocks should be located where the temperature averages between 40° and 70° F. For the laboratory sample, plunge the crocks well and fill a pint bottle nearly full, seal, and label with required date.

105. *Combined Evaporator and Dryer*.—The combined evaporator and dryer shown in Fig. 20 is specified in the official method of tannin analysis of the American Leather Chemists' Association for evaporative and drying



work required in tannin analysis. The lower part *a* is simply a copper water bath having a flat top. It is heated by either gas or steam. The hood, or upper part, *b* is double-walled, and the steam generated in the lower part comes through the elbows *c* and heats the hood, finally escaping through the vents *d*. The hood is hinged to the bath at the back end and is raised from the front when access to the drying chamber is desired. Air entering the holes *e* creates a draft and carries off through the chimney *f* the vapors of the liquors that are being evaporated. A water-level regulator *g* keeps the water in *a* at a constant level.

# MANUFACTURE OF SOAP

(PART 1)

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## INTRODUCTION

**1. Definition of Soap.**—By the term soap, in its strict acceptation, is meant the compound of an alkali, either sodium or potassium, with the higher fatty acids, especially with oleic, palmitic, and stearic acids. The insoluble compound of a fatty acid with a heavy metal is, however, technically called a soap. The chemist is familiar with the lead soap or lead plaster of the pharmacy, with alumina soap used as a thickener of lubricating oils, and with iron and chromium soaps used in dyeing and in the color printing of textiles.

As commonly known, soap is, according to its quality and the use for which it is intended, a mechanical mixture of the compound just described with varying proportions of water, with soluble alkali compounds of the rosin acids, with sal soda,  $Na_2CO_3 \cdot 10H_2O$ , with sodium silicate or soluble glass, or with other inert, deterative, or odoriferous agents, incorporated for the purpose of cheapening the product, improving its appearance, increasing the deterative action, or overcoming the natural odor with an agreeable perfume. Therefore, commercial soap is a mixture of pure soap with a diluent, as water; with body-imparting substances, as talc, starch, or a petroleum residue; or with deterative agents in aqueous solution, as sodium carbonate, borax, or sodium silicate. These additions may all be present in a single soap, but the nature and amount of the additions present depend on the character of the soap itself and on the purpose for which it is intended.

**2. Classes of Soap.**—Three general classes of soap may be defined, namely, *industrial*, *household*, and *toilet*. In the first class are included so-called textile soaps used in the process of manufacture of cotton and woolen goods. In the second class are included the soaps that are consumed in various qualities and conditions by the laundry trade; and in the third class may conveniently be included shaving and medicinal soaps.

The discussion of the subject that follows will deal with the process of manufacture rather than with the use for which the product is intended.

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### GENERAL OUTLINE OF THE MANUFACTURE OF A SETTLED SOAP

**3.** The following outline gives a general idea of the various operations performed in the manufacture of a settled laundry or domestic soap. The relation of the different operations to one another is here made clear, and the following detailed descriptions of the different operations and processes rendered more intelligible.

*Source of Fatty Acids.*—In the definition of a soap just given, it was stated that a soap is a salt formed by the union of an organic acid of the higher fatty series with a metal, usually an alkali metal. The acid portion of soaps is derived from various animal and vegetable fats and oils, which are compounds of the organic acids just mentioned with glycerine.

*Soap Stocks.*—Any fat or oil used in the manufacture of soap is called a *soap stock*, and may be of either animal or vegetable origin. The various kinds and grades of soap stock used will be fully discussed later.

*Saponification.*—The operation by which oils and fats are combined with the alkali metals sodium or potassium to form soaps is called *saponification*. Technically, this term has a wider meaning, and applies to any operation that brings about a separation of an organic acid from an organic base.

When an animal or a vegetable fat is boiled with a caustic alkali, a double decomposition takes place. The products

are the alkali salts of the organic acids of the fats and glycerine.

*Graining and Settling.*—After the saponification is complete, the soap is *grained*, or brought into a somewhat granular condition, by the addition of certain salts or alkalies in whose solutions the soap is practically insoluble. When in this granular state, the soap separates from the impure liquor, or lye, which may be drained off.

*Crutching.*—The soap, after the preceding treatment, is introduced into a machine called a *crutcher*, where it is crutched, or stirred, until it is thoroughly mixed. Here, fillers, perfumes, etc. are introduced and incorporated into the soap.

*Framing.*—From the crutcher the soap is run by gravity to a rectangular box, called a *frame*, of proper dimensions, in which it is allowed to stand until of a suitable consistency for cutting into slabs and bars.

*Slabbing.*—The mass of solidified soap from the frame is first cut horizontally into slabs. This operation is called *slabbing* and is performed on a machine called a *slabber*. These slabs in turn are cut, on somewhat similar machines, into blocks of suitable dimensions for making finished cakes.

*Drying, Pressing, Etc.*—The rough blocks are now dried superficially until a thin skin is formed over them. They are then pressed into finished cakes in dies and wrapped and packed for shipment.

## RAW MATERIALS OF SOAP MANUFACTURE

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### ANIMAL SOAP STOCK

4. **Animal soap stock** occurs on the market in a variety of grades, depending on its origin and method of preparation. This stock constitutes the chief fatty material used by the soap maker. According to the part of the animal from which it is obtained and the method of rendering, it may be classified as *tallow*, *bone stock*, and *grease*. These classes of animal soap stock may again occur in various grades. In determining the quality, buyers, as a rule, depend on the simple tests of color, odor, and grain, supplemented by the titer, or hardness, test, which will be described later. In addition, the percentage of moisture, unsaponifiable matter, and impurities insoluble in cold carbon bisulphide, and the percentage of free fatty acids are determined. The last determination is of especial importance when the stock is considered with relation to its yield of glycerine.

5. **Tallow.**—The tallow used in soap making varies in its composition according to the part of the animal from which it is obtained and the nature of the food used in fattening the animal. Corn-fed cattle produce the firmest fat. The fat of mast-fed cattle is not so firm as that obtained from animals fattened on oil cake. Tallow consists of about 60 per cent. of stearin, 34 per cent. of olein, and 6 per cent. of palmitin.

6. The percentage of free fatty acids is not only a reliable index of the quality of the stock used by the renderer but is a telltale on the care that he has employed. The following conditions conducive to the formation of a high percentage of free fatty acids in the various grades of tallow may be enumerated:

1. Allowing the raw material to stand before rendering, especially in warm weather. After the death of the animal, decomposition immediately sets in, and the first step in the decomposition of tallow is the separation of the fatty anhydrides from the glycerol, which is immediately followed by the decomposition of the glycerine and its loss as such.

2. An excessively high temperature in rendering tends to increase the percentage of free fatty acids. The presence of water in the tissues and the influence of the high temperature in the rendering tank tend to the hydrolysis of the glyceride.

3. Rendering in closed vessels increases the percentage of free fatty acids. It will be clear that there prevail here conditions that are purposely introduced and maintained in the process for the saponification of glycerides with steam under pressure in the manufacture of fatty acids and glycerine.

**7. Bone Stock.**—The bone stock is intermediate in quality between tallow and grease and is obtained from fresh bones by rendering in a closed vessel under pressure.

**8. Grease.**—The commercial term grease is applied to all fatty material of animal origin that cannot be classified among such distinctive products as tallow, lard, etc. It is obtained from hides, kitchen refuse, recovered garbage, offal, dead animals, etc. While white grease will produce soap as good in color and general appearance as that made of tallow, it yields, owing to its high percentage of olein, a soap having a much softer body. Generally speaking, soap made from grease is darker than tallow soap. A boiling process and not a cold process should be employed, however, because it is necessary to remove the dark coloring matter and other impurities with the waste lyes, and also to eliminate all disagreeable odors.

**9. Relative Quality of Animal Soap Stock.**—The relative quality of these three general grades of animal soap stock, as shown by the free-fatty-acid determination and the influence of the season, is indicated in Table I.

TABLE I  
PERCENTAGE OF FREE FATTY ACIDS

Soap Stock	Summer	Winter
Tallow . . . . .	7.80	5.85
Bone stock . . . . .	10.68	6.64
Grease . . . . .	18.03	7.49

The significance of the free-fatty-acid determination will be fully shown when the various fats and oils are discussed with reference to their content and yield of glycerine and the changes incident to saponification.

MANUFACTURE OF ANIMAL SOAP STOCK

10. In the manufacture of animal soap stock the various grades of tallow are extracted from the fat-enclosing tissue that surrounds the intestines, muscles, and other organs of the animal. The feet yield specifically neatsfoot oil. The process of rendering consists essentially in the separation of the fatty matter from the enclosing animal tissue. Tallow was originally obtained by simply boiling the finely divided parts of the animal containing the fat in water and skimming from the surface of the water the fat thus disengaged from the membrane. Fleishy portions of the animal previously finely chopped and rendered in the manner just mentioned yield the kettle-rendered tallow used for edible purposes. Tallow, other than that of packing-house origin, is usually distinguished as country or city rendered. The former, being from fresher stock, yields a better quality of tallow.

11. **Steam Rendering.**—Steam-rendered tallow is obtained by subjecting the rough fat to a steam pressure of from 30 to 60 pounds per square inch in a closed vessel, such as is shown in Fig. 1. The top of the tank is on the floor level and is provided with a safety valve, a manhole *a* for introducing the rough fat, which is commonly conveyed in barrows, and a discharge pipe for the exit of fumes.

Near the middle of the tank are two draw-off cocks (not shown in the figure) for the removal of the liquid tallow. Water is admitted through a valve near the bottom. At the bottom of the tank is either a large gate valve *b* or a tightly fitting door for the discharge of the "soup." The *soup*, or *soup liquor*, as it is called in the packing house, consists of soft bones, solid residuum, and water highly impregnated with albuminous matter. The liquid portion is run off and evaporated to a sirupy consistency under a partial vacuum, and is afterwards mixed with the solid matter freed from an excess of liquor by compression in a fertilizer press. This material constitutes the *tankage* fertilizer of the packing house.

After charging, these tanks, which are usually arranged in a series, are tightly closed. Water is run in, if desired, and steam is turned on. The period of working varies from 4 to 10 hours, according to the size of the tanks, the quantity of material introduced, and the steam pressure. At the expiration of the rendering period, the fat is discharged by means of the draw-off cocks. When the last portions of fat are below the level of the draw-off cocks, water is admitted into the tank from below, and the fat floating on the surface of the water is thus completely discharged. The remaining contents of the tank is then dropped through the discharge gate at the bottom.

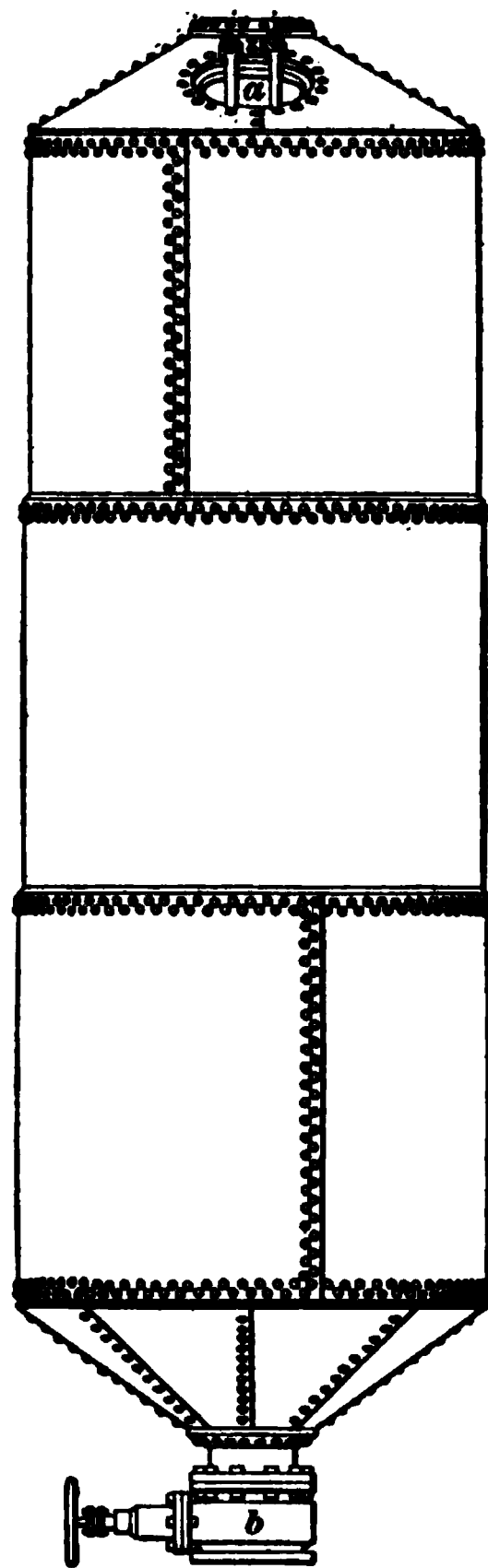


FIG. 1

**12. Chemical Rendering.**—While most of the animal stock used in the manufacture of soap is prepared by the steam-



rendering process, chemical rendering is carried on to a considerable extent. For this purpose, dilute liquors of either sulphuric acid or caustic soda are used, and the odorous substances present in the stock become partly destroyed or combined with the chemical agent used. If the acid process is employed, wooden or lead-lined tanks must be used for the operation.

### VEGETABLE SOAP STOCK

**13.** Any vegetable oil may be employed for the manufacture of soap, its applicability for this purpose being determined by its character, cost, and the use intended for the soap made from it. Linseed oil and the various nut oils—peanut oil, for example—cannot compete with cottonseed oil because of their greater initial cost. Castor oil is used but little, its very limited consumption being confined to the manufacture of transparent soaps. Linseed oil is used extensively in Europe in the manufacture of soft soap. In the United States soft soap finds only limited sale as a detergent. The soft soaps used in the cotton and woolen industries are made from a non-drying glyceride base. In Table II is given the average percentage yield of oils of vegetable origin. The percentage yield of oil from seeds, fruits, etc. is dependent on a variety of conditions, chief among which

**TABLE II**

**YIELD OF OIL FROM VARIOUS SEEDS, NUTS, ETC.**

Seed	Percentage Yield of Oil	Seed	Percentage Yield of Oil
Castor (Indian) .	51-53	Maize, or corn . .	6-10
Castor (American)	46-49	Olive (pericarp) .	40-60
Coconut . . . .	40-45	Palm (pericarp) .	65-72
Colza, or rape . .	33-43	Palm kernel . .	45-50
Cottonseed . . .	24-26	Peanut . . . . .	43-45
Linseed . . . . .	38-40	Sesame . . . . .	50-57

are the character of the soil, the weather, and the degree of ripeness, and these are subject to extreme variations. These conditions influence, as well, the specific gravity of one and the same oil. Moreover, according to the age, mode of preparation, etc. of the oil, the variations in specific gravity may be as great as the difference between the density of one oil and that of another serving as an adulterant.

**14. Cottonseed Oil.**—The chief product of cottonseed, which constitutes about two-thirds of the weight of the unginned cotton grown in the Southern States, is cottonseed oil. In recent years, this oil has attained great importance as a soap stock, although its use in this connection is small compared with its consumption for edible purposes. Crude cottonseed oil is a thick, reddish-brown to black oil of extremely varying quality, depending on the season and the care exercised in the collection and storage of the seed. The crude oil contains from 10 to 15 pounds of coloring matter per ton of seed. This coloring matter has been isolated, but is of little practical value. The loss in refining the crude oil amounts to from 5 to 7 per cent. This is an extremely varying factor, depending on the percentage of free fatty acids and the proportion of coloring and albuminous matter present, or, briefly, on the character of the seed. The yield of oil depends on the soil, season, and skill of manufacture, and ranges from 35 to 42 gallons of crude oil per ton of seed.

**15. Refining of Crude Cottonseed Oil.**—In the refining process, the first step is to separate as quickly and as thoroughly as possible the foreign matter from the expressed crude oil. The residue obtained on settling or filtration is known as *settlings* or *foots*. The precipitate, or residue, obtained in the refining process is sometimes termed "soap stock," but is known in the cottonseed trade as *cottonseed foots*, under which name it is sold. ("Foots" is a loose term at best, and "foots" and "soap stock" are frequently used indiscriminately.) The crude oil freed from settlings is now pumped into the first-treatment tank, where it is agitated

under increased temperature with caustic-soda lye of strength and proportion adapted to the quality of oil undergoing treatment. When sufficient time has elapsed for the complete absorption of the alkali, the agitation is ceased and the contents of the kettle is allowed to remain at rest. During this time the soap, which is formed by the combination of the free fatty acids with the caustic alkali and is contaminated with the organic impurities of the oil, settles to the bottom. The supernatant oil thus partly clarified is then transferred to the second-treatment tank, where it undergoes a bleaching process with fullers' earth. The proportion of fullers' earth used varies with the quality of the oil and may run from 2 to 5 per cent.; often a second treatment with fuller's earth after filtration is required.

The oil after agitation with fullers' earth, under increased temperature, is passed through the filter press. The filtrate constitutes the prime summer yellow cottonseed oil used in soap making. The various grades of edible and industrial cottonseed oils are obtained from this product by subsequent treatments with fullers' earth and filtration. The winter cottonseed oil used in miners' lamps requires limpidity at a low temperature. This condition is obtained by chilling the oil to a temperature below 0° C., whereby the so-called cottonseed-oil "stearin," which is really palmitin, separates.

**16. Grades of Cottonseed Oil.**—The requirements of the Texas Cottonseed Crushers' Association for the various grades of cottonseed oil compel a uniformity of quality that is absent in the soap stock of animal origin. The summer yellow oil employed in soap manufacture is usually examined for color, moisture, free fatty acids, and titer, the last test being of chief importance in determining comparative value for the use of soap makers.

**17. Crude Cottonseed Oil.**—The following are rules of the Texas Cottonseed Crushers' Association relating to cottonseed oil:

**Measurement.**—A tank (tank car) of cottonseed oil shall be 125 barrels. A barrel of oil, if sold loose, shall contain 50 gallons. A gallon of oil shall weigh  $7\frac{1}{2}$  pounds, avoirdupois.

**Classification.**—Crude cottonseed oil shall be classed and graded as follows:

**Choice crude** must be made from sound decorticated seed, must be sweet in flavor and odor, light in color, free from water and settlings, and test not over 1 per cent. of free fatty acids. It shall produce, when properly refined, choice summer yellow oil at a loss in weight not exceeding 6 per cent. for Texas oil, and at a normal loss for oil from all other parts of the country.

**Prime Crude.**—Crude cottonseed oil to pass as *prime* must be made from sound decorticated seed, must be sweet in flavor and odor, free from water and settlings, and must produce prime summer yellow grade by the usual refining methods with a normal loss in weight, provided the oil shall not be rejected for a nominal amount of settlings; but reasonable reduction shall be made in value for all such settlings in excess of  $\frac{1}{4}$  per cent.

**Off Oil.**—All oil neither choice nor prime shall be called *off oil*, and shall be sold by sample.

**18. Refined Cottonseed Oil.**—According to the rules of this association, refined cottonseed oil shall be classed and graded as follows, summer yellow oil only being considered:

**Choice summer yellow** must be sweet in flavor and odor, of light straw color, clear and brilliant in appearance, free from moisture, and must bleach to a choice white.

**Prime summer yellow** must be clear, sweet in flavor and odor, and of yellow color, not reddish, and free from water and settlings.

**Off Oil.**—This grade consists of all oils having any objectionable flavor or odor, or that are of a reddish color.

**19. Cottonseed-Oil Soap Stock.**—The precipitate obtained from the crude oil freed from settlings, on treatment with caustic-soda lye, consists of soap and free oil mixed with mucilaginous and coloring matters. This mixing undergoes further treatment with caustic alkali, which transforms all the free oil into soap. The finished soap is grained, and is then subjected to further brine and alkali washings in order to obtain a product as free from odor and light in color as possible. After this stock has been suitably purified and is on the final settling, it is run while hot and in a semifluid condition into barrels.

**20. Requirements of the Texas Cottonseed Crushers' Association for Soap Stock.**—According to the requirements of the Texas Cottonseed Crushers' Association, all sales, unless otherwise agreed on by buyer and seller, are on a basis of 50 per cent. of fatty acid, not to fall below 40 per cent. If containing less than 40 per cent. of fatty acid, soap stock shall not be considered merchantable. Delivery is to be made in iron-bound hardwood packages or tank cars. A tank car of soap stock shall be 50,000 pounds for contract purposes.

**21. Coconut Oil.**—The fruit of the coco palm, the *Cocos nucifera* of the tropics, is the source of coconut oil. The oil is expressed from the pulp of the nut, which contains about 50 per cent. of oil. It occurs on the market in three general grades, namely, Cochin, Ceylon, and copra oil. The terms Cochin and Ceylon have reference to the geographical origin of the fruit.

Considerable coconut oil is produced in the West Indies and in the tropical parts of America. That from Trinidad compares very favorably in color, body, and odor with the Cochin grade; but that from Cuba is inferior in quality and yellowish in color, and therefore cannot be used for the better grades of bath and floating soaps. Cochin coconut oil is usually sufficiently superior in quality to command a price of from  $\frac{1}{2}$  to 1 cent a pound more than Ceylon oil.

*Cochin coconut oil* is expressed from fruit grown in Cochin-China and adjacent territory, and on the islands of the China Sea.

*Malabar and Manila oil* is of good quality. Mauritius and the Fiji Islands also produce considerable. The coco palm is a native of Cuba, and at one time oil crushing was a thriving industry on that island.

*Ceylon coconut oil* is a product of the island of Ceylon and of the adjacent regions. The different grades of coconut oil arise from the varying skill and the nature of the apparatus employed in its recovery, some of the apparatus being very crude. Where improved milling machinery has been intro-

duced, coconut oil of uniform and superior quality is obtained; the greater part of the oil, however, is extracted by the most primitive methods. The oil arrives at the factory in immense casks, pipes, puncheons, and hogsheads containing from 800 to 2,000 pounds.

*Copra coconut oil* is made from the dried pulp or meat of the coconut, called *copra*. This pulp yields, on steaming and pressing, the lowest grade of coconut oil. The best oil of this grade is obtained from the ripest and most quickly pressed copra. Owing to its high percentage of the lower fatty acids and to its greater exposure, the copra oil is more liable to rancidity than is oil of Ceylon and Cochin grades. The Ceylon and Cochin oils are expressed in the districts near the shipping ports, while copra is produced almost entirely in territory deficient in shipping facilities. Great quantities of copra are shipped to Marseilles, France, where the oil is expressed. In Sydney, New South Wales, copra crushing is a thriving industry.

**22.** Coconut oil as a soap stock possesses distinct and peculiar qualities that define it sharply from all other animal and vegetable oils. In this connection, it may be well to note that there is no sharp distinction between a fat and an oil. Fat, which is usually of animal origin, is the term generally applied to the glycerides that are sold at ordinary temperatures; oil, on the other hand, may be of either animal or vegetable origin and is liquid at ordinary temperatures.

**23. Palm-Kernel Oil.**—In its chemical composition and behavior toward saponifying agents, palm-kernel oil is closely allied to coconut oil. While it is used extensively in Europe, it finds only limited application in the United States as a soap stock. It is expressed from the kernel of the palm nut, the fleshy envelope of which is the source of palm oil. The oil is white and has an agreeable odor and taste, but on aging it becomes rancid. Oudemans gives the following as the approximate composition:

GLYCERIDE		PER CENT.
Olein	. . . . .	26.6
Stearin	} . . . . .	33.0
Palmitin		
Myristin		
Laurin	} . . . . .	44.4
Caprin		
Caprylin		
Caproin		

24. **Palm Oil.**—The fleshy part of the fruit of the palm tree, the *Elæis Guineensis* and the *Elæis melanococca*, native along the west coast of Africa, is the source of palm oil. According to its source and the mode of expressing it, palm oil is of butter-like to tallowy consistency, varying in color from orange to dark red, and possesses a characteristic violet-like odor.

The oil can be bleached by blowing air through it for a number of hours while the oil is maintained at a temperature of from 80° to 90° C. But this can be accomplished better and more quickly by chemical bleaching, which destroys the odor as well as the color.

The chemical bleaching of palm oil is carried out in the following manner: After carefully removing all water and impurities by subsidence, the oil, cooled to a temperature of 105° to 110° F., is pumped into a lead-lined tank. While being constantly agitated by air,  $\frac{3}{4}$  of 1 per cent. of bichromate of soda dissolved in the least possible amount of water is run in, followed by  $1\frac{1}{2}$  per cent. of hydrochloric acid and  $\frac{1}{4}$  per cent. of sulphuric acid. At the end of 20 minutes the bleaching will be finished, and the acids and oxide of chromium are removed by allowing 25 per cent. of hot water to run in. It is preferable to allow the contents of the tank to remain undisturbed over night and to remove the clear oil in the morning.

The *Lagos oil* is the best quality made; it is of a deep, reddish-orange color and contains free fatty acids averaging from 20 to 30 per cent. The common grades of palm oil

are yellow in color, and on account of the primitive methods employed in extracting them, the free fatty acids are very high, running from 50 to 80 per cent. Deductions for moisture, dirt, and impurities are allowed on sales made, provided they amount to over 2 per cent., which is generally the case.

Since the titer of palm oil is very uniform, never varying much from 44° to 45° C., the chief industrial chemical tests made are the determinations of the impurities and of the free fatty acids present.

**25. Corn Oil.**—The germ obtained as a by-product in the manufacture of starch and glucose from maize is utilized in expressing corn oil. This oil is closely allied to cotton-seed oil in its soap-making properties. It is usually of a bright-yellow color, but may be bleached with fullers' earth to whiteness, as is done with certain edible grades of cotton-seed oil. Corn oil is used chiefly as a cheapener of paint oils.

In the manufacture of the oil, the corn is first steeped in water, so as to loosen the hull from the grain, which becomes swollen and tough from the absorption of water. The steeped kernel is then passed between rollers to separate the envelope and the starch from the softened germ, which remains whole and of the size of a grain of rice. The crushed corn is then transferred to tanks filled with water, in which the crushed grains sink, leaving the germs to float on the surface. These are removed, cooked, and compressed for the oil.

On account of its higher titer, from 33° to 35° C., cotton-seed oil as a soap stock is much to be preferred to corn oil, the titer of whose fatty acids ranges from 17° to 19° C.. Corn oil mixed with other stocks is used quite extensively in the production of soaps of soft body, to be used in the manufacture of soap powders. This mixture gives a soap readily soluble in cold or lukewarm water, a characteristic very essential to a good powder.

**26. Olive Oil.**—The pulp, or fleshy portion, of the fruit of the olive tree, the *Olea Europæa*, native in the Mediterranean



countries, is used for making olive oil. In these countries, olive oil has been employed from the earliest time as the fatty base of Castile soap. The use of olive oil for this purpose has of late years been largely displaced by the cheaper cottonseed oil, large quantities of the latter being exported from the United States to Marseilles for this purpose. Olive oil is used chiefly as an edible oil, and inferior grades only are used in the soap kettle. Olive oil finds very limited use as a soap stock in the United States. It contains about 72 per cent. of olein and 28 per cent. of palmitin, and behaves like cottonseed oil toward saponifying agents.

In the manufacture of olive oil, about 10 bushels of olives is crushed at a time in an edge-stone mill. The pasty mass that results, consisting of pulp and stones, is then placed in filter cloths and subjected to hydraulic pressure. The first pressing of the olives yields the finest oil. After the first pressing, which yields the virgin oil, as it is sometimes called, the press cake is ground up with water in the edge-stone mill, and the paste is then subjected to a second pressing. The second pressing yields an oil of inferior quality. The press cake after the second pressing still contains a large quantity of oil, which, when recovered, constitutes the olive-oil foots of commerce. Table III shows the specific gravity, weight per gallon, etc. of the principal fatty oils.

**27. Olive-Oil Foots.**—The oil remaining in the press cake after the second pressing may be extracted in either of two ways, but when recovered it is of such inferior quality as to be suitable only for industrial purposes. It is fairly fluid, dark green to black in color, and has a disagreeable odor. Its inferiority results from being contaminated by the green coloring matter and pulp of the fruit. To recover the remaining oil, the press cake is first well ground, hot water being added during the process. The dark pasty mass is then transferred to a tank and agitated with water until the broken olive stones drop, free from pulp, to the bottom of the tank. The oily residuum floating on the surface of the water is then transferred to another tank, where the free

oil is removed. The pulp residuum is again pressed and yields some oil. Olive-oil foots obtained in this manner are said to be "washed."

**TABLE III**  
**SPECIFIC GRAVITY AND WEIGHTS PER GALLON OF FATTY**  
**OILS AT 15° C. (60° F.)**

Name of Oil	Specific Gravity	Weight per Gallon		Trade Weight per Gallon Pounds
		Pounds	Ounces	
Almond oil . . . . .	.919	9	3	9
Arachis (groundnut) oil	.920	9	3	9 $\frac{1}{4}$
Castor oil . . . . .	.964	9	9 $\frac{1}{2}$	9 $\frac{1}{2}$
Coconut oil . . . . .	.925	9	4	
Cottonseed oil . . . . .	.923	9	4	9 $\frac{1}{4}$
Lard oil . . . . .	.912	9	2	9
Linseed oil . . . . .	.932	9	5 $\frac{1}{2}$	9 $\frac{1}{4}$
Neatsfoot oil . . . . .	.914	9	2 $\frac{1}{2}$	9
Olive oil . . . . .	.915	9	2 $\frac{1}{2}$	9
Palm oil . . . . .	.940	9	6	
Rape oil . . . . .	.914	9	2	9
Sesame oil . . . . .	.923	9	4	9 $\frac{1}{4}$
Tallow oil . . . . .	.912	9	2	9
Tallow . . . . .	.940	9	6	

The press cake may also be extracted with a volatile solvent, carbon disulphide being commonly used. The broken press cake is agitated with the solvent, after which the solution thus obtained is transferred to a covered tank. Here the solvent is distilled off and collected for subsequent use, leaving the recovered oil behind. This oil is black and retains the odor characteristic of the solvent. It is inferior to "washed" foots. This process, however, possesses the advantage of completely extracting the oil.

Soap made from olive-oil foots retains the green color of the recovered oil; the color, however, gradually bleaches out on exposure.

**28. Red Oil.**—In the manufacture of candles, a by-product known as red oil is obtained. This oil consists almost wholly of oleic acid, and derives its name from the color that it acquires on aging. The color, however, is chiefly due to contact with the iron. Red oil occurs in two grades, namely, *saponified* and *distilled red oil*.

**Saponified red oil** is obtained by either acid, lime, or aqueous saponification under pressure, in specially constructed tanks called autoclaves, or digesters. The mixed fatty acids resulting from saponification are resolved roughly into stearic and oleic acids by pressure through filter cloths. The stearic acid still remaining in the liquid portion is separated by chilling, whereby the commercial oleic acid, or red oil, is obtained.

**Distilled red oil** is obtained by distilling the mixed fatty acids with steam. By means of the process of fractional condensation, fatty acids of different melting points are separated. Distilled red oil varies in its composition according to the method employed in its manufacture. The following are analyses of two samples of commercial oleic acid:

INGREDIENTS	SAMPLE A	SAMPLE B
	PER CENT.	PER CENT.
Color . . . . .	Pale	Brown
Oleic acid . . . . .	93.06	87.70
Oil . . . . .	6.04	9.41
Hydrocarbons . . . . .	.90	2.89
Total . . . . .	100.00	100.00
Specific gravity . . . . .	.897	.904
Turbid at . . . . .	42° F.	38° F.

Red oil is a valuable soap stock. It admits of a nearly complete saponification with soda ash, as will be fully explained elsewhere.

**29. Manufacture of Saponified Red Oil.**—Saponified red oil, as just stated, may be obtained by three methods of saponification, namely, lime saponification, acid saponification, and aqueous saponification.

**30. Lime-Saponification Process.**—The digester, or autoclave, used in the lime-saponification process, is a strongly built tank, usually of copper, although some are made of iron, from 3 to 5 feet in diameter and from 18 to 25 feet in height. The digester may be set up either horizontally or vertically. It is covered with an asbestos jacket, to retain the heat, and is provided with a safety valve, a cock for the removal of samples, and a pressure gauge. At one end are located pipes for the introduction of the tallow and lime, for the discharge of the contents of the digester after saponification, and for the introduction of live steam.

The tallow is previously purified, if required, by boiling in weak brine and then allowing the impurities to subside. The brine wash is then run off, and the tallow is maintained in a fluid state by means of a closed steam coil. The quantity of unslaked lime commonly used for saponification is from 2 to 4 per cent. of the weight of the tallow. Both the tallow and lime tanks are on an elevation above the digester, and after the lime has been thoroughly mixed with water and the tallow melted, they are allowed to run by gravity into the digester. The charging of the digester may be hastened by creating a partial vacuum in it by the condensation of steam previous to running in the charge.

After the charge has been added, steam is turned on and maintained at a pressure of from 8 to 10 atmospheres for a period of from 4 to 10 hours, or until the saponification is complete; 8.7 per cent. of lime is theoretically required, but under the conditions maintained in the digester, from 2 to 4 per cent. has been found to be sufficient in practice. Samples are removed from time to time and tested for unsaponified matter. On completion of saponification, the contents of the digester is blown into wooden tanks, or vats, situated above the digester.

The mass resolves itself into two layers: the supernatant lime "rock," consisting of lime soap and fatty acids, and the "sweet" water, in which is dissolved the glycerine liberated from the stock. The glycerine solution is now allowed to flow by gravity to the glycerine plant, while the lime rock

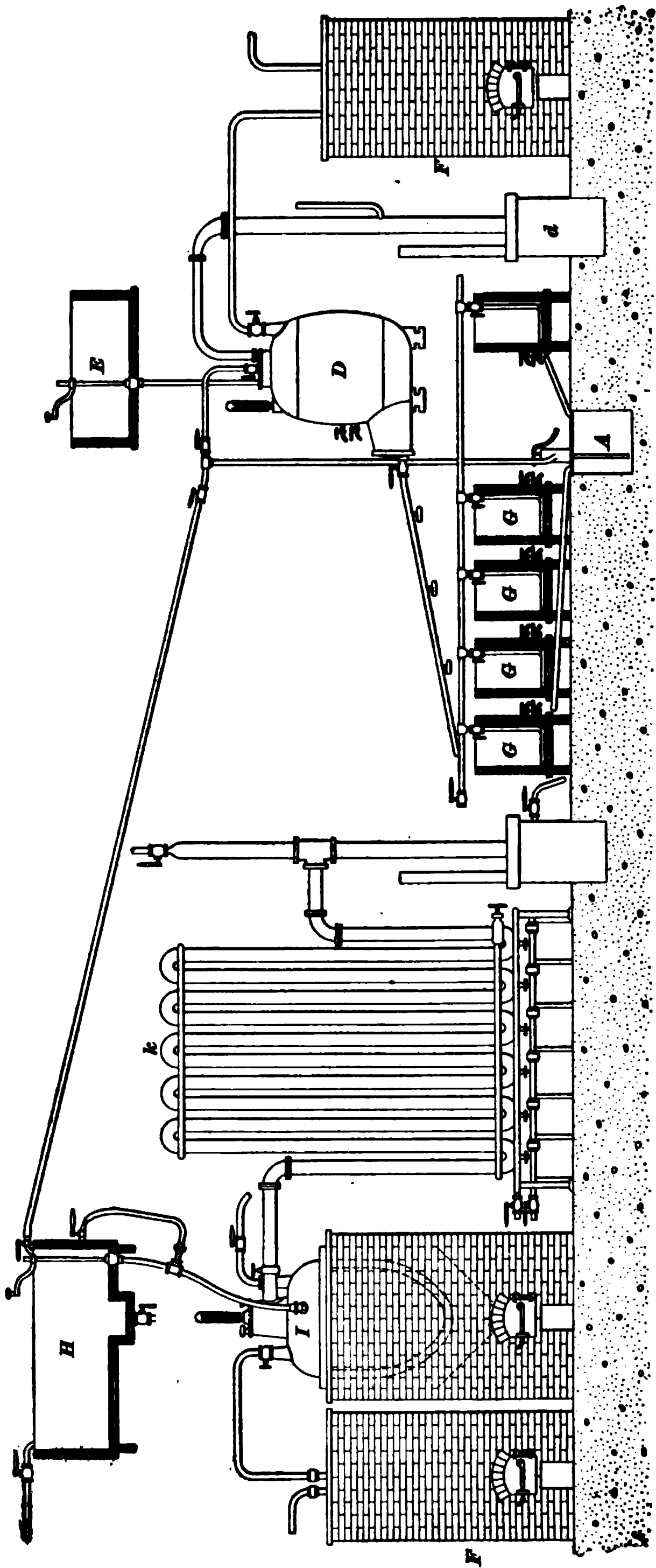


FIG. 2

is again boiled up with water and live steam in order to remove the last traces of glycerine. This wash liquor is removed as before.

The decomposition of the lime rock is effected by adding slowly, under constant agitation, the calculated quantity of dilute sulphuric acid. The fatty acids of the lime soap are thus set free. The mass at once resolves itself into two layers: the supernatant layer, consisting of the total fatty acids, and the water containing the calcium sulphate in solution and as a precipitate. The acid liquor and precipitate are now discharged into the sewer, and the fatty acids are washed free from all traces of sulphuric acid.

**31. Acid-Saponification Process.**—In Fig. 2 is shown a type of apparatus of English manufacture employed in the acid-saponification process for the manufacture of fatty acids for candle stock.

The raw material, whether it be tallow, palm oil, recovered grease, or any fatty body containing stearin, is first melted in the tank marked *A* and is then transferred to the storage tanks *G*. These tanks are wooden and lead-lined and are provided with acid-resisting steam coils. In these storage tanks the fat undergoes a preliminary purification, as already briefly described. The mass is then transferred to the acidifier marked *D*. It is here treated with from 4 to 12 per cent. of concentrated sulphuric acid, which is introduced by gravity from a tank *E* located immediately above. In the acidifier *D*, the mixture is subjected to the action of superheated steam furnished by the superheater *F*. To condense the acid vapors evolved during the reaction, a jet condenser provides a slight vacuum in the acidifier, and the vapors are thus drawn over and discharged into the reservoir *d*.

After the acidification is complete, the material is discharged into the storage tanks *G*, where the acid liquor is removed and the fatty acids are washed free from all traces of acid.

**32. Aqueous-Saponification Process.**—Many establishments manufacturing candle stock employ neither acid

nor lime in the hydrolysis of the glyceride, but saponify their tallow, bone fat, or other stock merely in the presence of water and under a steam pressure of 150 pounds. Saponification by means of water is the simplest and most convenient of the three processes described, inasmuch as the lime and acid treatments are made unnecessary. The process otherwise is carried on in precisely the same manner as described in the lime-saponification method.

**33. Distillation of the Fatty Acids.**—The fatty acids, whether obtained by the lime, acid, or aqueous saponification, are subjected to the same process of distillation. When made of pure and fresh raw material, the resulting fatty acids are of sufficiently good color to press immediately. The dark-colored fatty acids before pressing are subjected to distillation with superheated steam. Referring to Fig. 2, the fatty acids are pumped to the charging tank *H* situated on an elevation above the still *I*, into which these acids may flow by gravity. The still, generally of copper or copper-lined, is of variable capacity. A still of ordinary size will accommodate from 16,000 to 18,000 pounds at a "run," during which the volume of material in the still is kept constant by the addition of fatty acids from the charging tank above. As shown in Fig. 2, the still is incased in brickwork and is heated externally by fire and within by superheated steam, which passes through copper coils from the superheater *F*. The products of distillation are condensed in the vertical cooling tubes *k*, which connect at the bottom with coils immersed in warm water. The condensed fatty acids are here melted, to admit of their easy removal. The distillate is commonly collected in three fractions, namely, the first-run oil, comprising three-fourths of the total charge; the second-run oil, which is returned to the charging tank and redistilled with the next run; and the final portion, called from its color *green oil*. The residue in the still is known as *candle tar*.

**34. Pressing the Fatty Acids.**—The fatty acids, whether having been subjected to a previous distillation or

used directly from the autoclave, are transferred to square, shallow pans, or trays, supported on shelves in the granulating room. These trays are of enameled iron and are so placed that each tray, beginning at the end, is at a higher elevation and slightly over the succeeding one. It is thus possible to fill every pan in the series by running the melted fatty acids into the topmost, which, when full, overflows into the succeeding one, and so on until all are filled. Were the fatty acids cooled rapidly, the crystals of the fatty acids of different melting points would be so closely interlocked that the oleic acid could not be readily separated from the stearic. By allowing the mixture of fatty acids to cool slowly for a period of from 2 to 3 days in the granulating room, at a temperature of about 80° F., the stearic acid crystallizes in a menstruum of the liquid oleic acid. There is thus obtained at the expiration of this stage of the process a cake of stearic acid colored brown by the oleic acid.

The pan is now inverted on a woolen or a camel's-hair cloth, on which the cake falls. When the required number of cloths have been filled, they are transferred to the hydraulic press. Each cloth with its contents is separated by an iron plate. Pressure is applied very gradually at first, whereupon the crude oleic acid, or red oil, is expressed. The oil is then conducted to storage tanks, from which it either is run to the department in which it is used or is barreled for shipment.

The first pressing separates about 50 per cent. of the oleic acid present and is done cold. The cakes thus obtained are subjected to a second pressing between hollow iron plates heated with steam. The hot pressing is effected in a horizontal hydraulic press. The stearic acid now obtained is of snowy-white appearance and very hard and brittle. It melts at from 52° to 55° C. and is ready for the candle manufacturer.

**35. Comparison of the Processes for the Manufacture of Fatty Acids.**—The yield of solid fatty acids from tallow by lime saponification is from 44 to 48 per cent. Aqueous saponification admits of a slightly higher yield, namely, 50 per cent., from the same raw material; acid



saponification yields upwards of 55 per cent. of fatty acids. It is found in practice that distilled stock yields a press cake of lower melting point than that obtained from fatty acids used directly from the autoclave. This fact, taken together with the greater yield of the acid-saponification process, with which process distillation is used, may be explained by the polymerizing action of the sulphuric acid on the oleic acid in the still, whereby a body is formed of sufficient firmness to resist being expelled from the press cake with the crude oleic acid, and thus remains to lower the melting point and to add to the yield.

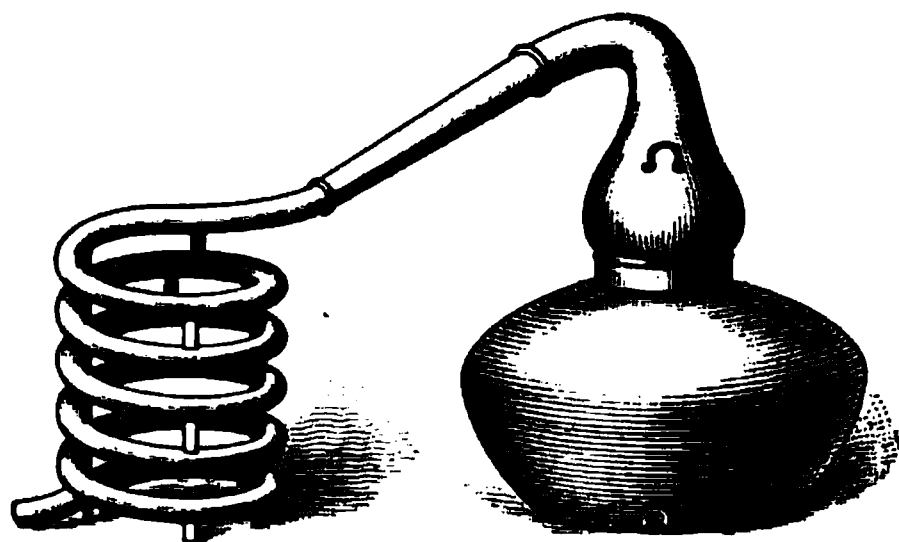


FIG. 8

With lime saponification, practically all the glycerine, upwards of 10 per cent., is obtained; with the acid saponification, not more than 3 per cent. is recovered. If it is desired to recover as much glycerine as is

possible, in addition to the solid fatty acids, the lime saponification is preferable. If fatty acids are the sole desideratum, the distillation process is better.

**36. Rosin.**—The solid residue left on the distillation of crude turpentine is **rosin**. The rosin, or crude turpentine, exudes from the pine tree, chiefly the long-leaf yellow pine of the Southeastern Atlantic and Gulf States. This rosin is of whitish color and of semisolid consistency. A number of deep incisions are made in the trunk of the tree starting about 1 foot from the ground, and each incision, or “box,” holds about a quart of the crude rosin. The number of boxes cut in each tree depends on the size of the tree. As the season advances, the flow of rosin is increased by removing the bark and wood to the depth of 1 inch above the box. At regular intervals, the exuded rosin is collected and distilled.

The still (see Fig. 3) used for distilling rosin is made of copper and varies in capacity from 10 to 50 barrels of crude turpentine. It is mounted on brickwork and has a furnace underneath. After the still has been charged, some water is run in and the contents is heated. The fire is increased gradually until the contents of the still has reached the boiling point, which temperature is maintained until practically all the volatile matter has been distilled over. As the distillation proceeds, water is added from time to time so as to replace that lost by evaporation and to prevent the product from being darkened by incipient burning. The distillate, separated from the water that has distilled over with it, constitutes the oil of turpentine of commerce. The hot liquid residuum in the still is now discharged through a valve near the bottom, is strained through sieves of increasing mesh up to No. 80, usually three in number, and is finally run into barrels. A charge of 12 barrels of crude turpentine, weighing upwards of 4,500 pounds, will yield on distillation about 3,600 pounds of rosin and about 900 pounds of oil of turpentine.

**37.** The gross weight of a barrel of rosin is about 500 pounds and the net weight averages 420 pounds, the barrel itself always being paid for at the same rate as the rosin. Rosin is marketed on a basis of 280 pounds to a barrel, and according to law, the empty barrel may weigh 15 per cent. of the weight of the barrel when filled. This is equivalent to 40 pounds for Alabama and 70 pounds for Savannah cooperage.

Opaque rosins contain turpentine and water, and when used in soaps they affect the hardness to a certain extent; that is, the soaps become soft in very hot weather.

There are about fifteen grades of rosin, varying in color from "water white," which is clear and almost colorless, to the lowest grade, commercially known as "C. A.," which is black. The various qualities arise from the length of time during which the crude rosin is collected from a single "camp."

The first year's run furnishes the best grades, while with each succeeding year a more inferior grade is obtained. The following grades are used in the soap industry:

- W. W., or Water White.
- W. G., or Window Glass.
- N., or Extra Pale.
- M., or Pale.
- K., or Low Pale.

Rosin is graded by sample, a  $\frac{7}{8}$ -inch cube being cut from the head of each barrel. Uniformity of size is important, as the thickness of the cube determines the shade of color, and therefore the value. Those who buy and sell rosin are provided with sample cubes representing the quality of the standard grades. The determination of the quality of a shipment, therefore, is simply a matter of comparing the sample cubes with those of the standard grades.

38. Rosin is acid in its composition, consisting of the anhydrides of the so-called rosin acids. Like red oil, rosin can be almost entirely saponified with soda ash. The alkaline salts of the rosin acids, while not constituting a true soap, possess marked detergent properties and are a valuable ingredient of household soap. The English were the first manufacturers of rosined soaps.

As rosin decreases in quality from the brighter to the darker grades, the percentage of unsaponifiable matter increases, as is indicated by the following determinations of the unsaponifiable matter:

MARKS	PERCENTAGE UNSAPONIFIABLE MATTER
W. W. . . . .	3.07
W. G. . . . .	3.88
N. . . . .	4.08
M. . . . .	6.34
K. . . . .	6.62

The coloring matter present in rosin is the cause of the high color of the waste soap lye withdrawn after the rosin change in the manufacture of settled rosin soap.

### ALKALIES AND THEIR MANUFACTURE

**39. Soda Ash.**—All the commercial sodium compounds start from common salt as a raw material. Before the development of the Le Blanc process, potash was used exclusively as the saponifying agent in the primitive soap manufacture of those days. The potash was obtained by burning seaweeds and lixiviating the ashes. The solution thus obtained was then causticized with quicklime. During the embargoes of the French Revolution, the supply of potash was cut off from France. As the result of a prize offered by the French government for a practical method of manufacturing soda ash from common salt, the Le Blanc process was given to the world. So perfectly was this process outlined in its original specifications that it has undergone no change in its essential principles in its entire history.

**40. The Le Blanc Process for the Manufacture of Sodium Carbonate.**—The manufacture of soda ash, or sodium carbonate,  $Na_2CO_3$ , from common salt by the Le Blanc process is carried on practically in three stages, as expressed in the following reactions:

1. Common salt, or sodium chloride, is converted into sodium sulphate by treatment with sulphuric acid.



The hydrochloric-acid gas is absorbed by passing it through towers down which water is allowed to trickle. The aqueous solution of the gas thus obtained constitutes the muriatic acid of commerce.

2. The sodium sulphate obtained by the preceding reaction is mixed with coal and fused in specially constructed furnaces. The coal reduces the sulphate to sulphide.



3. The sodium sulphide is now heated with carbonate of lime, which then reacts to form calcium sulphide and sodium carbonate.



The product of this reaction is crude soda, or black ash. The fused mass is allowed to cool and is then broken into fragments and lixiviated with water. The sodium carbonate in solution is allowed to crystallize out as  $Na_2CO_3 \cdot 10H_2O$ . The water of crystallization is expelled by heat, leaving the sodium carbonate or soda ash of commerce.

41. The Le Blanc process, although a creation of French ingenuity, enjoyed its greatest development on English soil, and for half a century was one of the chief mainstays of England's industrial supremacy. The practical employment of the process involved certain technical and many unsanitary disadvantages, whose baneful effects proved a constant encouragement for the development of a simpler and more hygienic process. The mechanical difficulties surrounding the production of alkali by what is now known as the *ammonia process* met their first practical solution at the hands of Ernest and Alfred Solvay, and in the past 35 years there have been established in every civilized country works operating the process originally covered by the Solvay patents. The first ammonia-soda works were established in Belgium in 1863. Later, immense works were established in England by Brunner, Mond & Co., whose name is closely associated with the development of the process in Great Britain.

The Le Blanc process has received the most thorough scrutiny of the best scientific minds, and the efforts made to enable it to survive in the face of the more economical production of a competing process have resulted in the most complete economy of operation. As a remunerative producer of alkali, the ammonia process early displaced it, with the result that the process is dependent for its profits entirely on its chlorine products. As yet no economical production of bleaching powder from the calcium-chloride waste of the ammonia-soda process has been wrought out on an extensive commercial scale, and as these two rival chemical processes stand today, the Le Blanc has command of the chlorine industry, while the scepter of remunerative alkali production has passed to the ammonia process.

**42. Solvay, or Ammonia-Soda, Process.**—The Solvay process for the production of soda ash from common salt is based on the precipitation of sodium bicarbonate in an ammoniacal solution of common salt by means of carbonic-acid gas. Practically all soda ash now produced is obtained by this process.

In the practical operation of the Solvay process, the employment of labor is reduced to a minimum. The materials employed in the direct manufacturing processes are either in a gaseous state or in aqueous solution. The fundamental chemical reaction of the process is as follows:



The salt is dissolved in water to form a very pure and concentrated brine. It is then saturated with ammonia gas. The liquor thus formed is introduced under pressure into the "carbonating" tower at a distance about one-third from the top. The carbonating tower is upwards of 65 feet in height and is made up of segments about 3.5 feet high and 6 feet in diameter. The carbonic-acid gas is forced into the tower through the bottom segment and is made to ascend in bubbles by means of a perforated plate covering a hole in the bottom of each segment. The reaction indicated by the preceding formula takes place in the carbonating tower. The success of the ammonia-soda process depends on the insolubility of the sodium bicarbonate in a cold, ammoniacal solution of common salt. The heat produced by the chemical reaction is taken up by cold water circulating in cooling pipes placed in each segment of the carbonating tower.

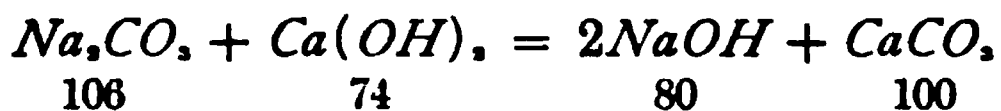
**43.** As the reaction proceeds, the precipitated sodium bicarbonate accumulates in the bottom of the tower, from which place it is withdrawn from time to time as a thick, milky liquid, containing ammonium chloride and sodium chloride in solution and the sodium bicarbonate in suspension. The solid bicarbonate is separated from the chlorides of ammonium and sodium in solution by means of centrifugal machines, and it is then washed with water to remove traces of these impurities. The bicarbonate is then calcined to

form a normal carbonate in accordance with the following reaction:



The Solvay soda ash thus obtained has a specific gravity of only .8, owing to its extremely finely divided condition. To increase the ease of handling this soda ash and to bring it up to the density of Le Blanc soda ash, namely, 1.2, it is made more compact by subjecting it to a second ignition. It is then ground and packed in bags and casks for shipment. Soda ash made by this process is much purer than the Le Blanc soda ash. It contains only traces of salt and bicarbonate and is free from the sulphide, sulphate, and hydrate of sodium.

**44. Caustic-Soda Manufacture.**—The manufacture of caustic soda is based on the following reaction:



According to this reaction, 100 pounds of sodium carbonate will yield on causticization 75.4 pounds of sodium hydrate. In the manufacture of caustic soda from the soda ash of the Le Blanc process, the lime is added to the solution obtained by lixiviating the black ash. The solution must not have a density in excess of 13° Baumé, or a reversion of the calcium carbonate will result. The impure solution of sodium carbonate is therefore diluted, if necessary, and the "milk of lime" added. Under heating and agitation with air, the reaction represented by the preceding formula takes place. Zinc oxide is added to reduce the sodium sulphide; thus,



The addition of sodium nitrate, together with the air used for agitation, suffices to oxidize any thiosulphate to the normal sulphate. The solution is then allowed to settle, and the supernatant solution of caustic soda is removed and evaporated until a density of 33.5° Baumé is attained, at which point most salts present as impurities crystallize out. The solution is then transferred to a heavy cast-iron pan,

and the evaporation is continued over fire until all water is expelled and the caustic soda remains as a fused mass.

A sample representing the contents of the kettle is tested for total alkali. If found to be below 60 per cent. in quality, the contents is worked up to that test. If the test indicates the quality to be above 70 per cent., the product may be worked into the highest grade or into that grade testing most closely to the contents of the kettle. The reduction of quality to the grade of caustic desired is effected by the addition of salt. The fused caustic soda is then run directly into sheet-iron drums and sealed to prevent exposure to the atmosphere. Owing to the greater purity of the solutions, purer caustic soda can be more easily obtained from the Solvay process soda ash than from Le Blanc soda ash. With Solvay soda ash it is not necessary to remove the impurities always characteristic of the commercial products of the Le Blanc process.

45. Although the production of caustic lye from soda ash by the soap maker may be effected at nominal cost, the use of the solid caustic, aside from other considerations peculiar to each works that may determine the installation of a causticizing plant, possesses superior advantages regarding cleanliness and convenience of working. The commercial production of solid caustic dates from 1854, at which time improvements introduced in its manufacture by William Gossage, in England, resulted in its more general use, although in a very impure state, by soap manufacturers and paper makers. Artificial alkali was first used in the manufacture of soap in 1823. It was manufactured in England by James Muspratt and according to the Le Blanc process. The Lancashire soap boilers were loath to accept this new and purer article, and it was only after Muspratt had distributed gratis scores of tons of Le Blanc soda that they became convinced of the superior economy of artificial over natural soda. The use of the sheet-iron drums was introduced by Thompson in 1857, this innovation being a most welcome improvement over cooling the liquid caustic



on iron slabs and subsequently breaking it into pieces and packing in barrels for shipment.

**46. Causticization of Soda Ash in the Soap Factory.** The causticizing plant consists essentially of a converting kettle, in which the chemical reaction indicated in Art. 44 is carried out, and a filter for the separation of the *lime mud*. The causticizing plant is shown in its essential characteristics in Fig. 4. It is required to causticize the soda

FIG. 4

ash as completely as possible, and for this reason the lime should be free from impurities. In causticizing a ton of soda ash, lime containing 2 per cent. of calcium sulphate will convert 42 pounds of a ton of soda ash into the less valuable product, sodium sulphate.

The solution of the soda ash in water is effected in the converting kettle *a* with the aid of live steam introduced through the pipe *b*, and the required amount of lime is shoveled in. The contents of the kettle is thoroughly agitated and boiled up with live steam, after which it is allowed to settle. The supernatant liquor is then pumped off through

the swing-joint pipe *c*. The lime precipitate, or mud, is boiled up with water and dropped on the filter *D*, where it is drained and washed. In some instances this lime waste, known as *whiting*, is recovered. This product is utilized in the manufacture of putty and in the paper industry as a make-weight, or filler.

47. As shown by experiments carried out by Lunge, the results of which are given in Table IV, the causticization is most complete with dilute solutions of soda ash.

**TABLE IV**  
**COMPLETENESS OF CAUSTICIZATION OF SOLUTIONS OF**  
**SODA ASH OF VARIOUS STRENGTHS (LUNGE)**

Per Cent. $Na_2CO_3$ in Liquor	Specific Gravity Before Causticizing	Per Cent. $Na_2CO_3$ Made Caustic by Treatment	
		Test No. 1	Test No. 2
2	1.022 at 15° C.	99.4	99.3
5	1.052 at 15° C.	99.0	99.2
10	1.107 at 15° C.	97.2	97.4
12	1.127 at 15° C.	96.8	96.2
14	1.150 at 15° C.	94.5	95.4
16	1.169 at 30° C.	93.7	94.0
20	1.215 at 30° C.	90.7	91.0

It is claimed for the apparatus shown in Fig. 4 that a caustic-soda solution of 14.5° Baumé, equivalent to 600 pounds of 77-per-cent. caustic, can be obtained from 800 pounds of 58-per-cent. soda ash and 650 pounds of lime. As a solution of caustic soda of this density is too dilute when soap is boiled on open steam, evaporation of the weak caustic lye to the required density is resorted to when the facilities of the factory permit.

48. **Electrolytic Production of Caustic Soda.**—It has long been known that when a current of electricity is passed through a solution of sodium chloride the same is decomposed into its positive and negative ions, appearing,

respectively, at the negative and positive poles, or, as they are called, the *cathode* and the *anode*.

When a solution of sodium chloride is thus electrolyzed, chlorine will appear at the anode and sodium at the cathode. Chlorine, being gaseous, will either pass into solution or be discharged into the atmosphere; sodium, being a very active element, immediately decomposes the water surrounding the cathode, forming sodium hydrate and liberating hydrogen. Many varieties of electrolytic cells have been designed, with varying degrees of success, to serve as a commercial producer of caustic soda and chlorine. The chief mechanical difficulty in the production of a satisfactory electrolytic cell

FIG. 5

lies in the character of the diaphragm, which serves to separate the products liberated from the positive and negative poles. Chlorine must not be allowed to diffuse through the brine, as secondary reactions are set up. The problem is to find a satisfactory medium that will prevent the diffusion of the liberated products and at the same time offer no resistance to the passage of the electric current.

**49. Castner Electrolytic Process for the Production of Caustic Soda and Chlorine.**—In the Castner cell, mercury is used to separate the chlorine liberated at the positive pole, or anode, and the sodium liberated at the negative pole, or cathode. The cell, as shown in Fig. 5, is essentially a box made of slate slabs and divided into three

compartments marked *e*, *f*, *g*. Compartments *e* and *g* contain the salt solution and the carbon anodes *a*, while compartment *f* contains the caustic-soda solution and the iron cathode *c*. Sufficient mercury covers the bottom of the cell to alloy with the sodium as it is liberated. By means of the cam *b* the cell is subjected to a slight oscillation on the pivot *d*. In this manner, the sodium-mercury amalgam is carried into compartment *f*, where the amalgam acts as the anode to the iron cathode *c*, the sodium being set free to combine with the water in compartment *f*. The electrolysis of the brine takes place in compartments *e* and *g*. The sodium immediately alloys with the mercury, which serves to carry the alkali into compartment *f*, where the formation of caustic soda takes place. A regulated supply of water is run into the middle compartment to combine with the sodium, which is allowed to flow out as a dilute caustic-soda solution in corresponding volume. The chlorine gas is removed by exhaustion from compartments *e* and *g*.

The Castner process is employed industrially at Niagara Falls for the production of caustic soda and bleaching powder, and appears to be one of the most successful devices of its kind that has yet been developed.

**50. Comparison of the Methods of Alkali Manufacture.**—The Le Blanc process for the manufacture of commercial alkali products is able to survive in the face of the cheaper Solvay process with its absence of waste products, only by virtue of its production of hydrochloric-acid gas as a by-product.

So long as no cheaper method for the manufacture of muriatic acid is developed, the Le Blanc process will continue to be an important industry. In other respects, the Solvay process possesses every advantage.

The several electrolytic processes that have taken practical shape during the past few years have assumed a productive importance that will increase with each succeeding year. The problem of their commercial success is being gradually brought to a satisfactory solution, and what influence they

may exert on the firmly established chemical processes is being watched with no little interest. As a producer of alkali, it is not likely that the ammonia process will be assailed. The older chemical process, which has so long monopolized the manufacture of bleaching powder, has most to fear from the growth of the electrolytic methods.

To sum up the essential differences between the chemical and electrolytic methods for the production of sodium compounds, it may be stated that the electrolytic process is direct, clean, labor saving, and free from worthless by-products. On the other hand, its units of plant are small, troublesome, expensive, and rapidly deteriorate with use. The chemical process provides a large output with comparatively few large units of plant of rather simple construction. The repairs, though costly, are not numerous and do not have to be applied to a vast number of small pieces of apparatus. To the disadvantage of the chemical process, it may be said to be arduous and that fairly skilled labor is required for its operation; also that a number of by-products, invariably troublesome and of little or no value, are produced.

**51. Grading of Soda Ash.**—The system of grading soda ash and caustic soda is based on the molecular composition of these bodies. The quotations of the various grades in terms, respectively, of 48-per-cent. alkali and 60-per-cent. caustic is handed down from the early Le Blanc days and is an evidence of the highest grades of those products they were then able to produce mechanically. The molecular weight of sodium carbonate,  $Na_2CO_3$ , is 106, composed of 62 parts by weight, or 58.49 per cent., of  $Na_2O$ , the remainder being  $CO_2$ . A soda ash that contains 58.49 per cent. of  $Na_2O$  is therefore chemically pure, this percentage being equivalent to 100 per cent. of  $Na_2CO_3$ . A 58-per-cent. alkali should contain 58 per cent. of  $Na_2O$  or its equivalent, 99.16 per cent. of  $Na_2CO_3$ ; likewise, a 48-per-cent. alkali should contain 48 per cent. of  $Na_2O$  or its equivalent, 82 per cent. of  $Na_2CO_3$ . The reduction of any grade of soda to that of 48 per cent. is effected by admixture with common salt.

Following are presented for comparison two fairly representative analyses of these two standard grades of soda ash:

GRADE	PER CENT.	PER CENT.	PER CENT.	PER CENT.	$F_2O_3$	$Al_2O_3$	$CaCO_3$	
PER CENT.	$Na_2CO_3$	$NaCl$	$Na_2SO_4$	$NaOH$	$SiO_2$		$MgCO_3$	$H_2O$
48	60.64	28.34	4.35	1.29	1.12		Traces	4.26
58	98.72	.54	.20		.10		.17	.26

**52. Grading of Caustic Soda.**—Caustic soda occurs on the market in a variety of grades and is sold on the basis of 60 per cent. of  $Na_2O$ . Caustic soda as a product of the alkali industry did not appear until 30 years after the industry was established in Great Britain, and the expression of its quality in the same terms as that of soda ash might therefore be expected. The molecular weight of caustic soda is 40; to arrive at sodium oxide,  $Na_2O$ , as an expression of the customary unit, 2 molecules, with a total molecular weight of 80, are used. In  $2NaOH$  there are 62 parts, or 77.5 per cent. of  $Na_2O$ , the remainder being  $H_2O$ . Therefore, a chemically pure caustic soda contains 77.5 per cent. of  $Na_2O$ , or its equivalent, 100 per cent. of  $NaOH$ . Following is given for comparison the percentage of the essential ingredient corresponding to, but never present in, the various grades of caustic commonly found in the market:

GRADE	PER CENT.
	$NaOH$
60	77.42
70	90.32
72	92.90
74	95.48
76	98.06
77	99.35
77.5	100.00

Sodium chloride, sodium carbonate, and sodium sulphate, in varying proportions, constitute chiefly the remainder of the ingredients. With the present system of grading, based on the chemical determination of the total alkali, the  $Na_2O$  of the  $Na_2CO_3$  is estimated with the  $Na_2O$  in terms of which the caustic soda, or  $NaOH$ , is expressed. With this method of expressing the quality of the caustic, the soap maker has just cause for complaint in that a variable percentage of an

ingredient not so valuable as the caustic soda is included in the total percentage of the essential ingredient present. The following is an industrial analysis of a sample of commercial caustic purporting to be of 74-per-cent. quality:

	PER CENT.
Total alkali, $Na_2O$ . . . . .	74.18
Total alkali, present as $NaOH$ . . . . .	69.88
Caustic alkali, $NaOH$ . . . . .	90.18
Combined alkali, $Na_2CO_3$ . . . . .	7.35
Sodium chloride, $NaCl$ . . . . .	2.02

This analysis indicates the sample to be of substantially 70-per-cent. quality. The difference between the sodium hydrate actually present and that claimed, namely, 4.30 per cent.  $Na_2O$ , is due to the 7.35 per cent. of  $Na_2CO_3$ , this being estimated as its equivalent, 4.30 per cent. of  $Na_2O$ , in the total sodium oxide. As more or less carbonate is invariably present in all commercial caustic, especially in the lower grades, the system of including it in the expression of the quality of this product is open to severe criticism. Quotations of quality are thus confessedly a misrepresentation. The only rational method is the expression of the  $Na_2O$  as free caustic, or preferably units of  $NaOH$ .

This would be an absolute index of the value of the caustic as a saponifying agent, and not, as by the method in vogue, an uncertain approximation of the same. English degrees indicate the strength of the ash or the caustic in terms of  $Na_2O$ , but owing to an error in atomic weights, English analyses indicate a greater percentage of  $Na_2O$  than is present. This error has become so firmly established by tradition that modern ideas have been unable as yet to eliminate it. In Germany and Russia, the strength is expressed in terms of sodium carbonate. This system is perfectly rational when applied to soda ash, but is inconsistent when applied to caustic. The expression of the value of commercial caustic soda in terms of an impurity is certainly not conducive to clear ideas on the subject, even though, in so far as the soap industry is concerned, this impurity is positively worthless as a saponifying agent for neutral glycerides.

**53.** The superior advantages and the economy of high-grade caustic need no argument. It is true of this product that the best, within certain limits, is the cheapest. There is presented in Table V the price per 100 pounds of sodium hydrate as it occurs in the customary grades of caustic, assuming that no carbonate is estimated as caustic.

**TABLE V**  
**PRICE OF SODIUM HYDRATE OF VARIOUS GRADES**

Grade Per Cent.	Price per 100 Pounds	Per Cent. of <i>NaOH</i> Present	<i>NaOH</i> per 100 Pounds
60	\$1.65	77.42	\$2.131
70	1.50 for 60%	90.32	1.937
74	1.60 for 60%	95.48	2.066
76	1.70 for 60%	98.06	2.196

The variation in prices quoted arises from the slight differences in cost of production of the lower grades, combined, for those grades, with the proportionally greater cost of packages, transportation, etc.

The total charges contingent on marketing a 60-per-cent. caustic are the same as those of a 70-per-cent., although the former contains considerably less of the essential ingredient; also, the cost of production of a 70-per-cent. caustic is but little more than that of a 60-per-cent. The increased cost of production of the higher grades, namely, 74 per cent. and 76 per cent., makes necessary a higher price, which is less than it would be if cost of marketing were correspondingly increased.

**54. Preparation of Caustic-Soda Lye.**—The solid caustic soda is delivered at the works in the familiar sheet-iron drums, containing usually about 675 pounds. The dissolving of the solid caustic is a simple operation. The method employed in effecting solution, the arrangement of the tanks, and the system of transferring the lye, vary with each establishment.



The work of solution is facilitated by inserting a false bottom, or cage, in the melting tank to support the solid

TABLE VI  
PERCENTAGE OF SODIUM HYDRATE, *NaOH*, IN LYES OF  
DIFFERENT DENSITIES, MADE FROM CAUSTIC  
OF VARIOUS GRADES

Specific Gravity	Degrees Baumé	77½% % <i>NaOH</i>	76% % <i>NaOH</i>	74% % <i>NaOH</i>
1.075	10	6.55	6.42	6.25
1.091	12	8.00	7.84	7.63
1.116	15	10.06	9.86	9.60
1.142	18	12.64	12.40	12.07
1.162	20	14.37	14.09	13.72
1.180	22	15.91	15.61	15.19
1.210	25	18.58	18.23	17.74
1.241	28	21.42	20.99	20.44
1.263	30	23.67	23.21	22.60
1.320	35	28.83	28.28	27.53
Specific Gravity	Degrees Baumé	72% % <i>NaOH</i>	70% % <i>NaOH</i>	60% % <i>NaOH</i>
1.075	10	6.08	5.91	5.06
1.091	12	7.43	7.22	6.19
1.116	15	9.34	9.08	7.78
1.142	18	11.74	11.41	9.78
1.162	20	13.35	12.97	11.12
1.180	22	14.78	14.36	12.31
1.210	25	17.27	16.78	14.38
1.241	28	19.89	19.33	16.57
1.263	30	21.99	21.37	18.32
1.320	35	26.79	26.04	22.31

caustic previously broken into lumps. With this arrangement, a natural circulation of liquor of different densities is set up, with the result that weak liquor continually rises to

the surface, while the saturated liquor, by virtue of its greater density, subsides. This eliminates the mechanical agitation that is necessary when the solid caustic is allowed to rest on the bottom of the tank.

**55.** In the preparation of caustic lyes of different densities from various grades of caustic, the effect of the impurities, chiefly sodium chloride, sodium carbonate, and sodium sulphate, is to reduce the active value of the solution for the specific gravity indicated. This reduction in saponifying power is least for the highest grades and greatest for the lowest, as a natural result of the increased percentage of these impurities present. There is arranged in Table VI the percentage of sodium hydrate present in lyes of different densities, made from the usual grades of caustics, corresponding to the densities of lye made from chemically pure caustic. It is assumed that the total alkali is present entirely as caustic, which never actually occurs. The figures stated, for reasons previously given, are slightly higher than would be found in practice. However, this table possesses some value as a basis of comparison, and for many technical purposes the figures are sufficiently accurate.

**56.** In the preparation of caustic-soda lye in the kettle room, the number of drums of caustic soda and the quantity of water required to furnish a lye of a certain density will be learned by experience. In Table VII are given the densities of caustic-soda solutions made from chemically pure caustic soda.

**57. Caustic Potash.**—Potash, or crude potassium carbonate, was originally obtained from the ashes of seaweeds, and before the development of the Le Blanc process it provided the only saponifying agent then available. Later, wood ashes, beet-sugar residues, and wool scourings formed the chief commercial source. The various potassium salts are now obtained chiefly from the mineral carnallite, which is composed of the chlorides of potassium and magnesium with water of crystallization. Carnallite, with other minerals composed of chlorides and sulphates of the alkali and

**TABLE VII**  
**SPECIFIC GRAVITY OF CAUSTIC-SODA SOLUTIONS AT 15° C.**  
**(LUNGE)**

Specific Gravity	Degrees Baumé	Degrees Twaddell	Per Cent. $Na_2O$	Per Cent. $NaOH$	1 Cubic Meter Contains Kilograms	
					$Na_2O$	$NaOH$
1.007	1	1.4	0.47	0.61	4	6
1.014	2	2.8	0.93	1.20	9	12
1.022	3	4.4	1.55	2.00	16	21
1.029	4	5.8	2.10	2.71	22	28
1.036	5	7.2	2.60	3.35	27	35
1.045	6	9.0	3.10	4.00	32	42
1.052	7	10.4	3.60	4.64	38	49
1.060	8	12.0	4.10	5.29	43	56
1.067	9	13.4	4.55	5.87	49	63
1.075	10	15.0	5.08	6.55	55	70
1.083	11	16.6	5.67	7.31	61	79
1.091	12	18.2	6.20	8.00	68	87
1.100	13	20.0	6.73	8.68	74	95
1.108	14	21.6	7.30	9.42	81	104
1.116	15	23.2	7.80	10.06	87	112
1.125	16	25.0	8.50	10.97	96	123
1.134	17	26.8	9.18	11.84	104	134
1.142	18	28.4	9.80	12.64	112	144
1.152	19	30.4	10.50	13.55	121	156
1.162	20	32.4	11.14	14.37	129	167
1.171	21	34.2	11.73	15.13	137	177
1.180	22	36.0	12.33	15.91	146	188
1.190	23	38.0	13.00	16.77	155	200
1.200	24	40.0	13.70	17.67	164	212
1.210	25	42.0	14.40	18.58	174	225
1.220	26	44.0	15.18	19.58	185	239
1.231	27	46.2	15.96	20.59	196	253
1.241	28	48.2	16.76	21.42	208	266
1.252	29	50.4	17.55	22.64	220	283
1.263	30	52.6	18.35	23.67	232	299
1.274	31	54.8	19.23	24.81	245	316
1.285	32	57.0	20.00	25.80	257	332
1.297	33	59.4	20.80	26.83	270	348
1.308	34	61.6	21.55	27.80	282	364
1.320	35	64.0	22.35	28.83	295	381
1.332	36	66.4	23.20	29.93	309	399
1.345	37	69.0	24.20	31.22	326	420
1.357	38	71.4	25.17	32.47	342	441
1.370	39	74.0	26.12	33.69	359	462
1.383	40	76.6	27.10	34.96	375	483
1.397	41	79.4	28.10	36.25	392	506
1.410	42	82.0	29.05	37.47	410	528
1.424	43	84.8	30.08	38.80	428	553
1.438	44	87.6	31.00	39.99	446	575
1.453	45	90.6	32.10	41.41	466	602
1.468	46	93.6	33.20	42.83	487	629
1.483	47	96.6	34.40	44.38	510	658
1.498	48	99.6	35.70	46.15	535	691
1.514	49	102.8	36.90	47.60	559	721
1.530	50	106.0	38.00	49.02	581	750

alkaline earth metals, occurs in immense deposits near Stassfurt, Germany.

**Caustic potash** is manufactured from carnallite by the Le Blanc process. The potassium chloride is converted into potassium sulphate by treatment with sulphuric acid. A mixture is then obtained that is analogous to the crude Glauber's salt of the Le Blanc process. This mixture is fused with limestone and coal, and the resulting mass is lixiviated with water. The solution of potassium carbonate thus obtained is causticized with lime, and a solution of caustic potash results. This caustic liquor is removed, evaporated to dryness, and fused. While molten it is run into drums and comes into commerce as caustic potash. It is not so uniform in its composition as the corresponding sodium compound. Commercial caustic potash is a mixture of the following substances:

	PER CENT.
Carbonate and hydrate of potassium . . .	80 to 95
Chlorides of sodium and potassium . . .	5 to 10
Sulphate of potassium . . . . .	5 to 15
Insoluble matter . . . . .	1.5 to 3

A good caustic potash is generally opaque and of a dull-gray slate or bluish color, often streaked with red or greenish stains. It has a powerful affinity for moisture, and on exposure to the air, it deliquesces rapidly and soon becomes pasty. Sometimes, it presents a whitish appearance in the center of the drum, and occasionally it is honeycombed. That which contains a large proportion of salts is usually crystalline and very compact. Its high cost militates against its more general use as a saponifying agent; and it is used very little today in soap manufacture. On exposure to the air, its solutions rapidly absorb carbon dioxide, with the formation of the acid carbonate. It is a more active chemical agent than caustic soda. Caustic potash improves the quality of all soaps of which it is an ingredient. It cannot be used in settled soap manufacture with sodium chloride as the graining agent, because an interchange of alkalies would take place and much of the potassium would be lost as the

**TABLE VIII**  
**SPECIFIC GRAVITY OF SOLUTIONS OF CAUSTIC POTASH**  
**AT 15° C. (LUNGE)**

Specific Gravity	Degrees Baumé	Degrees Twaddell	Per Cent. $K_2O$	Per Cent. $KOH$	1 Cubic Meter Contains Kilograms	
					$K_2O$	$KOH$
1.007	1	1.4	.7	.9	7	9
1.014	2	2.8	1.4	1.7	14	17
1.022	3	4.4	2.2	2.6	22	26
1.029	4	5.8	2.9	3.5	30	36
1.037	5	7.4	3.8	4.5	39	46
1.045	6	9.0	4.7	5.6	49	58
1.052	7	10.4	5.4	6.4	57	67
1.060	8	12.0	6.2	7.4	66	78
1.067	9	13.4	6.9	8.2	74	88
1.075	10	15.0	7.7	9.2	83	99
1.083	11	16.6	8.5	10.1	92	109
1.091	12	18.2	9.2	10.9	100	119
1.100	13	20.0	10.1	12.0	111	132
1.108	14	21.6	10.8	12.9	119	143
1.116	15	23.2	11.6	13.8	129	153
1.125	16	25.0	12.4	14.8	140	167
1.134	17	26.8	13.2	15.7	150	178
1.142	18	28.4	13.9	16.5	159	188
1.152	19	30.4	14.8	17.6	170	203
1.162	20	32.4	15.6	18.6	181	216
1.171	21	34.2	16.4	19.5	192	228
1.180	22	36.0	17.2	20.5	203	242
1.190	23	38.0	18.0	21.4	214	255
1.200	24	40.0	18.8	22.4	226	269
1.210	25	42.0	19.6	23.3	237	282
1.220	26	44.0	20.3	24.2	248	295
1.231	27	46.2	21.1	25.1	260	309
1.241	28	48.2	21.9	26.1	272	324
1.252	29	50.4	22.7	27.0	284	338
1.263	30	52.6	23.5	28.0	297	353
1.274	31	54.8	24.2	28.9	308	368
1.285	32	57.0	25.0	29.8	321	385
1.297	33	59.4	25.8	30.7	335	398
1.308	34	61.6	26.7	31.8	349	416
1.320	35	64.0	27.5	32.7	363	432
1.332	36	66.4	28.3	33.7	377	449
1.345	37	69.0	29.3	34.9	394	469
1.357	38	71.4	30.2	35.9	410	487
1.370	39	74.0	31.0	36.9	425	506
1.383	40	76.6	31.8	37.8	440	522
1.397	41	79.4	32.7	38.9	457	543
1.410	42	82.0	33.5	39.9	472	563
1.424	43	84.8	34.4	40.9	490	582
1.438	44	87.6	35.4	42.1	509	605
1.453	45	90.6	36.5	43.4	530	631
1.468	46	93.6	37.5	44.6	549	655
1.483	47	96.6	38.5	45.8	571	679
1.498	48	99.6	39.6	47.1	593	706
1.514	49	102.8	40.6	48.3	615	731
1.530	50	106.0	41.5	49.4	635	756
1.546	51	109.2	42.5	50.6	655	779
1.563	52	112.6	43.6	51.9	681	811
1.580	53	116.0	44.7	53.2	706	840
1.597	54	119.4	45.8	54.5	731	870
1.615	55	123.0	47.0	55.9	754	902
1.634	56	126.8	48.3	57.5	789	940

chloride. Soaps containing it are milder in their deterative action, will stand more filling without efflorescence, and possess a tougher texture.

By virtue of their milder deterative action on animal and vegetable fibers, potash soaps—usually soft soaps—find wide application in the textile industry.

In Table VIII is given the specific gravity of solutions of caustic potash at 15° C., according to Lunge.

#### MEASUREMENT OF THE DENSITY OF LIQUIDS

58. The *specific gravity* of a liquid or solid is the expression of the relation between the weight of the liquid or solid and the weight of an equal volume of pure water at a definite temperature, usually 15° C. The most convenient and practical means of ascertaining the strength of solutions of carbonated and caustic alkalies is to determine their specific gravity with a *hydrometer*. As shown in Fig. 6, the hydrometer is simply a closed tube with a bulb blown in one end, containing a paper scale and filled with shot or mercury. When placed in a liquid, the weighted bulb enables the hydrometer to float in an upright position. The Baumé and Twaddell hydrometers are the instruments most commonly used, the Baumé hydrometer in America and the Twaddell hydrometer in England.

With the latter instrument, the density of pure distilled water is represented by zero, and the scale is graduated in such a manner that the specific gravity of the liquid may be calculated by multiplying the number of degrees registered on the scale by .005 and adding the product to 1; thus, the density of a liquid indicating 100° Twaddell would be  $100 \times .005 + 1.000$ , or 1.500. The Twaddell hydrometer is a *direct-reading instrument*. This means that the reading on the scale shows the specific gravity of the liquid directly as compared with pure water at the definite temperature.



FIG. 6

TABLE IX  
SPECIFIC GRAVITY AND DEGREES BAUMÉ FOR LIQUIDS  
HEAVIER THAN WATER  
(Temperature 10° R. = 12.5° C. = 54.5° F.)

Degrees Baumé	Specific Gravity	Degrees Baumé	Specific Gravity	Degrees Baumé	Specific Gravity	Degrees Baumé	Specific Gravity
0	1.00000	20	1.15497	39	1.35438	58	1.63701
1	1.00675	21	1.16399	40	1.36680	59	1.65519
2	1.01360	22	1.17316	41	1.37945	60	1.67378
3	1.02054	23	1.18246	42	1.39234	61	1.69279
4	1.02757	24	1.19192	43	1.40547	62	1.71223
5	1.03471	25	1.20153	44	1.41885	63	1.73213
6	1.04194	26	1.21129	45	1.43248	64	1.75250
7	1.04927	27	1.22122	46	1.44638	65	1.77335
8	1.05671	28	1.23131	47	1.46056	66	1.79470
9	1.06426	29	1.24156	48	1.47501	67	1.81657
10	1.07191	30	1.25199	49	1.48975	68	1.83899
11	1.07968	31	1.26260	50	1.50479	69	1.86196
12	1.08755	32	1.27338	51	1.52014	70	1.88551
13	1.09555	33	1.28436	52	1.53580	71	1.90967
14	1.10366	34	1.29552	53	1.55179	72	1.93446
15	1.11189	35	1.30688	54	1.56812	73	1.95989
16	1.12025	36	1.31844	55	1.58479	74	1.98601
17	1.12873	37	1.33021	56	1.60182	75	2.01283
18	1.13735	38	1.34218	57	1.61923	76	2.04038
19	1.14609						

The Baumé hydrometer is adapted for the determination of the specific gravity of liquids, either heavier or lighter than water (see Tables IX and X). The scale used is arbitrary and bears no direct relation to the specific gravity; hence, the conversion of the readings into the corresponding specific gravity is done by reference to tables prepared for this purpose. In Table XI are given the values of specific gravity corresponding to degrees Twaddell and degrees Baumé.

TABLE X  
SPECIFIC GRAVITY AND DEGREES BAUMÉ FOR LIQUIDS  
LIGHTER THAN WATER

Degrees Baumé	Specific Gravity	Degrees Baumé	Specific Gravity	Degrees Baumé	Specific Gravity	Degrees Baumé	Specific Gravity
10	1.0000	23	.9183	36	.8488	49	.7892
11	.9932	24	.9125	37	.8439	50	.7849
12	.9865	25	.9068	38	.8391	51	.7807
13	.9799	26	.9012	39	.8343	52	.7766
14	.9733	27	.8957	40	.8295	53	.7725
15	.9669	28	.8902	41	.8249	54	.7684
16	.9605	29	.8848	42	.8202	55	.7644
17	.9542	30	.8795	43	.8156	56	.7604
18	.9480	31	.8742	44	.8111	57	.7565
19	.9420	32	.8690	45	.8066	58	.7526
20	.9359	33	.8639	46	.8022	59	.7487
21	.9300	34	.8588	47	.7978	60	.7449
22	.9241	35	.8538	48	.7935	61	.7411

CHEMISTRY OF SOAP MANUFACTURE

59. In the preceding examination of the raw materials of soap manufacture there have been considered those bodies which carry the two compounds—namely, a glyceride and a caustic alkali—that, when in chemical combination, form soap. Soap boiling, therefore, consists essentially in bringing a fatty body and a caustic alkali in aqueous solution in contact under suitable conditions, whereby a simple chemical reaction takes place with the formation of an alkaline salt of a fatty acid and the liberation of glycerine. This reaction is known as *saponification*.

60. For the purpose of explanation, the fatty body will be represented by 1 molecule of stearin and the saponifying agent by 3 molecules of caustic soda; thus:

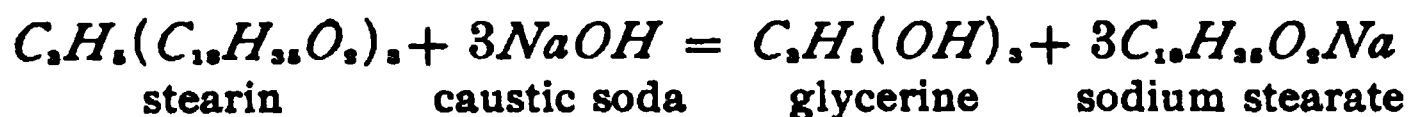


TABLE XI  
SPECIFIC GRAVITY, DEGREES TWADDELL, AND  
DEGREES BAUMÉ

Twaddell	Baumé	Specific Gravity	Twaddell	Baumé	Specific Gravity	Twaddell	Baumé	Specific Gravity	Twaddell	Baumé	Specific Gravity
0	0	1.000	44	26.0	1.220	88	44.1	1.440	132	57.4	1.660
1	.7	1.005	45	26.4	1.225	89	44.4	1.445	133	57.7	1.665
2	1.4	1.010	46	26.9	1.230	90	44.8	1.450	134	57.9	1.670
3	2.1	1.015	47	27.4	1.235	91	45.1	1.455	135	58.2	1.675
4	2.7	1.020	48	27.9	1.240	92	45.4	1.460	136	58.4	1.680
5	3.4	1.025	49	28.4	1.245	93	45.8	1.465	137	58.7	1.685
6	4.1	1.030	50	28.8	1.250	94	46.1	1.470	138	58.9	1.690
7	4.7	1.035	51	29.3	1.255	95	46.4	1.475	139	59.2	1.695
8	5.4	1.040	52	29.7	1.260	96	46.8	1.480	140	59.5	1.700
9	6.0	1.045	53	30.2	1.265	97	47.1	1.485	141	59.7	1.705
10	6.7	1.050	54	30.6	1.270	98	47.4	1.490	142	60.0	1.710
11	7.4	1.055	55	31.1	1.275	99	47.8	1.495	143	60.2	1.715
12	8.0	1.060	56	31.5	1.280	100	48.1	1.500	144	60.4	1.720
13	8.7	1.065	57	32.0	1.285	101	48.4	1.505	145	60.6	1.725
14	9.4	1.070	58	32.4	1.290	102	48.7	1.510	146	60.9	1.730
15	10.0	1.075	59	32.8	1.295	103	49.0	1.515	147	61.1	1.735
16	10.6	1.080	60	33.3	1.300	104	49.4	1.520	148	61.4	1.740
17	11.2	1.085	61	33.7	1.305	105	49.7	1.525	149	61.6	1.745
18	11.9	1.090	62	34.2	1.310	106	50.0	1.530	150	61.8	1.750
19	12.4	1.095	63	34.6	1.315	107	50.3	1.535	151	62.1	1.755
20	13.0	1.100	64	35.0	1.320	108	50.6	1.540	152	62.3	1.760
21	13.6	1.105	65	35.4	1.325	109	50.9	1.545	153	62.5	1.765
22	14.2	1.110	66	35.8	1.330	110	51.2	1.550	154	62.8	1.770
23	14.9	1.115	67	36.2	1.335	111	51.5	1.555	155	63.0	1.775
24	15.4	1.120	68	36.6	1.340	112	51.8	1.560	156	63.2	1.780
25	16.0	1.125	69	37.0	1.345	113	52.1	1.565	157	63.5	1.785
26	16.5	1.130	70	37.4	1.350	114	52.4	1.570	158	63.7	1.790
27	17.1	1.135	71	37.8	1.355	115	52.7	1.575	159	64.0	1.795
28	17.7	1.140	72	38.2	1.360	116	53.0	1.580	160	64.2	1.800
29	18.3	1.145	73	38.6	1.365	117	53.3	1.585	161	64.4	1.805
30	18.8	1.150	74	39.0	1.370	118	53.6	1.590	162	64.6	1.810
31	19.3	1.155	75	39.4	1.375	119	53.9	1.595	163	64.8	1.815
32	19.8	1.160	76	39.8	1.380	120	54.1	1.600	164	65.0	1.820
33	20.3	1.165	77	41.1	1.385	121	54.4	1.605	165	65.2	1.825
34	20.9	1.170	78	40.5	1.390	122	54.7	1.610	166	65.5	1.830
35	21.4	1.175	79	40.8	1.395	123	55.0	1.615	167	65.7	1.835
36	22.0	1.180	80	41.2	1.400	124	55.2	1.620	168	65.9	1.840
37	22.5	1.185	81	41.6	1.405	125	55.5	1.625	169	66.1	1.845
38	23.0	1.190	82	42.0	1.410	126	55.8	1.630	170	66.3	1.850
39	23.5	1.195	83	42.3	1.415	127	56.0	1.635	171	66.5	1.855
40	24.0	1.200	84	42.7	1.420	128	56.3	1.640	172	66.7	1.860
41	24.5	1.205	85	43.1	1.425	129	56.6	1.645	173	67.0	1.865
42	25.0	1.210	86	43.4	1.430	130	56.9	1.650			
43	25.5	1.215	87	43.8	1.435	131	57.1	1.655			







The process of effecting combination between a fat and an alkali, as just stated, is called saponification. This term is also applicable to a vast number of similar chemical changes in which an alcohol is set free and an acid is produced, when water is the saponifying agent, or an alkaline salt of the fatty acid, that is, soap, when the saponifying agent is an alkali.

### GLYCERIDES AND THEIR PROPERTIES

**61.** In order to understand thoroughly the soap-making properties of the various fats and oils and their behavior in the soap kettle, it is necessary to be familiar with the chemical properties of the various glycerides that constitute the fats and oils employed in soap manufacture. The variation in the amount of alkali absorbed by any particular fat or oil arises from differences in the composition of the glycerides themselves and from the varying proportions in which the glycerides occur in any particular stock. It is a well known fact that fats and oils are indefinite mixtures of various glycerides, and that the amount of alkali absorbed is influenced by the nature of the glycerides characteristic of the stock.

It will be seen from Table XII that the amount of alkali required for saturation decreases as the molecular weight of the glycerides increases. Hence, it will be found that those commercial fats and oils in which the glycerides of low molecular weight occur, possess the highest alkali absorption in proportion to their weight.

The greater quantity of salt required for graining the soap made from such stock is due to the presence of those glycerides of low molecular weight whose greater solubility in brine of the sodium salt is a marked characteristic. As the glycerides increase in molecular weight, the solubility in brine of the soap obtained therefrom diminishes; hence, less salt is required for graining.

TABLE XIII  
THEORETICAL YIELD OF ANHYDROUS SOAP

Glyceride and Chief Sources	Molec- ular Weight	Yield on Saponifi- cation With Water		Per Cent. Water Absorbed	Yield on Saponifi- cation With Caustic Soda		Per Cent. NaOH Absorbed
		Per Cent. Fatty Acids	Per Cent. Glycerine		Per Cent. Soap	Per Cent. Glycerine	
Laurin—coconut and palm-kernel oils	638	94.04	14.42	8.46	104.38	14.42	18.80
Myristin—palm-kernel oils . . . . .	722	94.74	12.75	7.48	103.87	12.70	16.63
Palmitin—palm oil and tallow . . . . .	806	95.28	11.41	6.69	103.47	11.41	14.88
Linolein—linseed oil . . . . .	878	95.68	10.48	6.16	103.19	10.48	13.67
Olein—olive and cottonseed oils . . . . .	884	95.70	10.40	6.10	103.16	10.40	13.56
Stearin—tallow and lard . . . . .	890	95.73	10.34	6.07	103.14	10.34	13.48
Recinolein—castor oil . . . . .	932	95.92	9.88	5.80	103.00	9.88	12.88
Arachidin—peanut oil . . . . .	974	96.10	9.44	5.54	102.87	9.44	12.31

NOTE.—As shown in *Organic Chemistry*, the homologous character of the simple hydrocarbons of the saturated and unsaturated fatty series extends to all compounds formed from them, either naturally or artificially. The purpose of Table XII is to illustrate this property by extending the quantitative characteristics of the more important acids to their corresponding glycerides, and more particularly to those employed in soap manufacture, which appear in heavy type. This table is of great practical interest from the standpoint of both the candle maker and the soap boiler, inasmuch as the most important practical properties of glycerides, namely, alkali absorption and glycerine liberation, are set forth in detail. It will be seen from the standpoint of the soap maker that to the acetic and acrylic series of fatty bodies belong the most important commercial glycerides, namely, stearin, palmitin, and olein, while to the more unsaturated series belong those glycerides characteristic of all drying oils, which are the special consideration of the paint manufacturer.

**62.** The homologous properties of the glycerides mentioned in the previous article and shown in Table XII, are further shown in their practical application in soap making in Table XIII, in which is indicated the theoretical yield of anhydrous soap from the glycerides mentioned.

**63.** The reason for the greater yield of soap from coconut oil than from the ordinary animal and vegetable fats is thus made clear. Not only is there a greater yield of anhydrous soap in itself, but by virtue of that higher yield a greater degree of hydration and "filling" is thus permissible. In Table XIV are given the actual and not the theoretical percentages of caustic potash and caustic soda required in practice to saponify the commercial fats and oils mentioned.

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#### BEHAVIOR OF FATS AND OILS TOWARD SAPONIFYING AGENTS

**64.** The various fats and oils display different characteristics in their behavior toward saponifying agents. Moreover, the chemical reactions of organic compounds do not proceed with the ease and certainty that characterize the reactions of inorganic compounds. In effecting combination between fats or oils and caustic alkalies in a soap kettle, where in many instances the fatty bodies are in excess of 100,000 pounds, the chemical peculiarities of the bodies undergoing change should in every case be thoroughly understood.

**TABLE XIV**  
**ACTUAL PERCENTAGES OF CAUSTIC POTASH AND CAUSTIC SODA FOR SAPONIFYING VARIOUS FATS AND OILS**

Fat or Oil	Per Cent. <i>KOH</i>	Per Cent. <i>NaOH</i>
Lard oil . . . . .	19.1-19.6	13.6-14
Almond oil . . . . .	19.5-19.6	13.9-14
Sesame oil . . . . .	19 -19.4	13.5-13.7
Rape oil . . . . .	17.1-17.9	12.2-12.8
Poppy-seed oil . . . . .	19.3-19.5	13.8-14
Niger-seed oil . . . . .	18.9-19.1	13.5-13.6
Whale oil . . . . .	18.8-22.4	13.4-16
Butter . . . . .	22.1-23.2	15.8-16.5
Palm-nut oil . . . . .	22 -24.7	15.7-17.7
Tallow . . . . .	19.3-19.8	13.7-14.1
Sperm oil . . . . .	12.3-14	8.8-10
Palm oil . . . . .	19.6-20.2	14 -14.4
Olive-kernel oil . . . . .	18.8	13.4
Olive oil . . . . .	19.1-19.6	13.6-14
Peanut oil . . . . .	19.1-19.6	13.6-14
Cottonseed oil . . . . .	19.1-19.6	13.6-14
Linseed oil . . . . .	18.7-19.5	13.3-14
Hempseed oil . . . . .	19.3	13.8
Walnut oil . . . . .	19.6	14
Seal oil . . . . .	18.9-19.6	13.5-14
Porpoise oil . . . . .	21.6	15.5
Coconut oil . . . . .	24.6-26.8	17.5-19.10
Lard oil . . . . .	19.2-19.6	13.7-14
Bone fat and grease . . . . .	19.1-19.7	13.6-14
Castor oil . . . . .	17.6-18.1	12.5-13
Cod oil . . . . .	18.5-21.3	13.2-15.1
Rosin . . . . .	17 -19.3	12.1-14

As will be explained later, the saponification of a fat is a progressive reaction, based on its chemical constitution as a triglyceride.

**65.** In a mixture of fats, the individual fats tend to impart their properties to one another. Certain oils, notably coconut and palm kernel, require caustic lye of high density to effect combination. With others, as tallow and palm oil, saponification takes place readily with caustic lye of lower density. When soap stocks with these characteristics are mixed, the requirements of each are modified so that an oil requiring for saponification alone a lye of high density enters into combination with lye of a density with which it would not combine otherwise without time-consuming and troublesome manipulation. On the other hand, that stock requiring naturally for ready saponification a lye of low density enters readily into combination with a lye of higher density. These peculiarities will be considered in due order.

**66. Saponification of Tallow.**—Tallow requires a caustic lye of comparatively low density for satisfactory saponification. A 12° Baumé lye, when no subsequent dilution is made, is considered to give the best results. On boiling with open steam, a lye of 18° to 20° Baumé is the highest density practicable. When open steam is used with caustic lye of this density, tallow is the most easily saponified of all glyceride soap stocks, and the soap formed is most easily grained.

Sodium stearate, which constitutes the bulk of the anhydrous soap made from tallow, is one of the least soluble in water of all the alkaline salts of the fatty acids, as it undergoes practically no change when treated with 10 parts of water; neither is its hardness appreciably affected. This quality manifests itself in the inferior lathering properties of pure tallow soap. Furthermore, on aging, a pure tallow soap becomes so hard as to give very little lather, so that its use is not economical for either household or laundry purposes. The comparative insolubility in water of sodium stearate is also shown in the readiness with which tallow soap dries. Its presence in admixture with other fats imparts firmness, or body, to the soap, thus enabling a greater proportion of softer stock, or that fatty acid whose sodium salt has a greater



affinity for water, to be incorporated. The use of sodium stearate thus increases the amount of water that may be incorporated with a soap without an excessive sacrifice of firmness. It is the best raw material for the manufacture of grained soaps and admits of the greatest yield of all the animal soap stocks. With its use, the various chemical and physical changes occurring in the soap kettle during the process of boiling are well defined and of easy recognition.

**67.** In Table XV is expressed the saponifying power of caustic lyes of different densities made from chemically pure and from the ordinary grades of caustic occurring in the market. By referring to this table, the amount of stock that can be saponified by any quantity of lye of the density and quality given may be readily determined within limits of accuracy suitable for all technical purposes to which the table may be applicable.

**68. Saponification of Cottonseed Oil.**—Refined cottonseed oil saponifies with difficulty and only after continued boiling, especially when saponified alone. The absence of free fatty acids tends to retard saponification. Combination with alkali is hastened when tallow is present, or upon the addition of soap scraps. Saponification is best begun with a 15° Baumé lye.

Pure cottonseed-oil soap is white, with a firmness determined largely by its degree of hydration. It consists almost entirely of sodium oleate. This compound is soluble in 10 parts of water, while sodium stearate, as already shown, is not appreciably affected by this volume. In accordance with its greater solubility in water, sodium oleate has in comparison, greater and peculiar lathering properties. It lathers more readily than does sodium stearate, but instead of the firm lather of tallow soap, obtained only after much rubbing, it gives a shiny, thin lather peculiar to all soaps made of stock consisting largely of olein, namely, Castile soap and cottonseed-oil soap stock. Cottonseed oil is generally used in admixture with varying proportions of tallow and grease.

A good settled soap of cottonseed oil alone is not practicable. Soap thus made is "thin" and lacks the body and durability of a tallow soap or a soap made from mixed stock. By the use, however, of a large proportion of soda ash and sodium silicate, an artificial firmness may be imparted.

Cottonseed-oil soaps "sweat" readily, and unless the oil has been refined with care, they discolor rapidly and become rancid. The brownish or yellowish blotches seen in soaps

TABLE XV  
POUNDS OF TALLOW SAPONIFIED BY 100 POUNDS OF  
CAUSTIC SODA OF DIFFERENT DENSITIES MADE  
FROM VARIOUS GRADES OF CAUSTIC

Density, Degrees Baumé	Grade of Caustic Soda					
	77½ Per Cent. <i>Na<sub>2</sub>O</i>	76 Per Cent. <i>Na<sub>2</sub>O</i>	74 Per Cent. <i>Na<sub>2</sub>O</i>	72 Per Cent. <i>Na<sub>2</sub>O</i>	70 Per Cent. <i>Na<sub>2</sub>O</i>	60 Per Cent. <i>Na<sub>2</sub>O</i>
	Tallow Saponified Pounds	Tallow Saponified Pounds	Tallow Saponified Pounds	Tallow Saponified Pounds	Tallow Saponified Pounds	Tallow Saponified Pounds
10	46.78	45.86	44.66	43.45	42.24	36.20
12	57.14	56.03	54.55	53.08	51.59	48.49
15	71.85	70.46	68.60	66.74	64.88	60.96
18	90.02	88.26	85.94	83.62	81.28	69.66
20	102.64	100.60	97.95	95.30	92.64	79.39
22	113.64	111.40	108.50	105.50	102.60	87.92
25	132.71	130.10	126.70	123.30	119.90	102.70
28	153.00	150.10	146.10	142.10	138.10	118.40
30	169.07	165.80	161.40	157.00	152.60	130.80
35	205.92	201.90	196.60	191.30	186.00	159.30

containing cottonseed oil may be traced to the imperfect removal of the coloring matter of the seed during the refining process.

**69. Saponification of Coconut and Palm-Kernel Oils.**—Coconut and palm-kernel oils differ from all fatty bodies employed in soap manufacture in the greater quantity of alkali required for saponification, in the greater quantity of salt required for graining, and in the greater yield of soap

produced, the quality of which permits the greatest amount of hydration and filling.

Pure coconut-oil soap is white, brittle, and hard. The oil is a valuable addition to cottonseed oil and tallow, and it yields a soap possessing qualities superior to that possessed by either stock alone. It enters into combination with alkali with extreme ease, which property especially adapts it for soap manufacture by the cold process.

During saponification considerable heat is evolved, and when once begun, saponification takes place with such rapidity that the contents of the kettle, unless carefully watched, will boil over. On the stock change (stock saponification), difficulty is often experienced in working with coconut oil, or a mixture of oils containing coconut oil, the soap mass becoming thick easily. This is due to the high absorption of water consequent on rapid saponification and may be overcome by retarding the rate of combination of caustic alkali and oil. This is best effected by adding brine when the soap mass shows signs of becoming thick. It may also be avoided by adding the oil slowly to the caustic alkali already in the kettle, at the same time boiling vigorously.

**70.** Coconut oil combines with weak and strong caustic lyes with equal facility, but in practice in the boiling of settled soap, a density of from 20° to 25° Baumé is commonly used. Coconut-oil soap when hot is very fluid, smooth, and transparent; when cold, it becomes so hard as to be cut only with difficulty. It dissolves readily in water, yielding a quickly formed, profuse, but not permanent, lather. It is caustic to the tongue even though no free alkali is present, and when used for toilet purposes in excess of actual requirements it irritates and reddens the skin. If coconut oil is not completely saponified, the soap made from it soon becomes rancid and odorous. It dissolves freely in salt water and is the fatty basis of the so-called marine, or salt-water, soaps.

**71.** The complex composition of coconut oil suffices to explain the peculiarities of its behavior toward saponifying

agents and the properties of the soap made from it. Coconut and palm-kernel oils contain a greater variety and quantity of glycerides of fatty acids of low molecular weight than any other soap stock.

As will be seen by referring to Table XIII, these bodies possess a higher alkali absorption, yield a greater percentage of glycerine on saponification, are more soluble in water when free and combined with alkali, and, in general, possess less stable chemical properties than do similar bodies of higher molecular weight that occur commercially as soap stock.

**72. Saponification of Palm Oil.**—Palm oil, of which palmitin is the chief glyceride, finds only limited use as a soap stock in the United States. This oil is used chiefly as an ingredient of certain toilet-soap bases (for which purpose it is well adapted by its perfume) and to disguise the odor of rosin in excessively rosined soap. In Great Britain and Continental Europe, however, it replaces tallow to a large degree.

Sodium palmitate so closely resembles sodium stearate in its chemical properties that the statements concerning the properties of the latter salt are directly applicable to it. Palm oil saponifies very readily, owing to the high percentage of free fatty acids characteristic of the oil.

**73. Saponification of Rosin, or Colophony.**—Rosin when in a pure state consists of the anhydrides of the rosinic acids, chiefly abietic acid,  $C_{19}H_{19}(CO_2H)$ . On boiling, rosin is readily transformed into the acid, which combines with both carbonated and free alkali. In ordinary practice, rosin is seldom "killed," or saponified, alone, but is added after the kettle has been charged with tallow. The tallow may be saponified previously or both stocks may be killed together. The difficulty with which a pure rosin soap separates, or grains, in even a concentrated salt solution is the chief reason for it not being saponified alone. This is due to the fact that the specific gravity of rosin ranges from 1.07 to 1.10, while that of tallow is about .9. Also, in ordi-

nary practice, soda ash is seldom used as the saponifying agent. The rosin soap thus made is frothy from the liberation of carbonic-acid gas, and as a result of the increased volume caused in this manner, much kettle space is required to work it. However, where factory conditions are such as to warrant the use of soda ash instead of caustic soda, a considerable saving is possible, as is shown in the following approximate calculation:

EXAMPLE.— 6,000 pounds rosin  $\times .13 = 780$  pounds, approximately, of 74-per-cent. (see Table XIV) caustic soda required for combination;  $\frac{74}{100} \times \$1.75 = \$2.16$ , cost per 100 pounds of 74-per-cent. caustic soda when price is \$1.75 per 100 pounds for 60 per cent.;  $\$2.16 \times 7.8$  hundredweight = \$16.85, cost of 74-per-cent. caustic soda, required for combination.

$$\begin{array}{l} 2NaOH : Na_2CO_3 = 780 : x \\ \text{or} \quad \quad \quad 80 \quad : \quad 106 = 780 : x \end{array}$$

$x = 1,033.5$  pounds soda ash required for combination.

$1,033.5 \times \$0.009 = \$9.30$ , cost of soda ash required for combination.

Caustic soda costs . . . . .	\$16.85
Soda ash costs . . . . .	9.30
Saving in alkali for 6,000 pounds of rosin . . . .	\$ 7.55

74. The alkali salts of the rosin acids are very hygroscopic and naturally readily soluble in water, and, as should be expected, make a very soft soap. They detract from the firmness of all soaps in which they enter. Rosin betrays its presence in the finished soap by the darker color and by its characteristic odor and stickiness, which latter property is due to the marked affinity of the alkaline resinsates for moisture. This peculiarity manifests itself in the readiness with which all rosined soaps sweat. The marked detergent property, ready solubility in either hot or cold, soft or permanently hard water, and cheapness of the alkaline resinsates, make them an indispensable addition to the firmer tallow soap for domestic purposes. The characteristic odor may be ameliorated by the addition of suitable perfumes, and the stickiness may be reduced by the admixture in reasonable proportions of the tallow and rosin base. Highly rosined soaps become very dark on aging.

**75.** The best proportions of tallow and rosin to employ depend primarily on the firmness of the tallow; that is, on the percentage of stearin present. A soft tallow cannot assimilate so much rosin as a firm tallow and the desired firmness of the finished soap be obtained.

It has been the custom of the trade to rate rosined soaps according to the proportion that the rosin bears to the fat stock by what is known as soap-makers' percentage. A 100-per-cent. rosin soap contains equal parts of tallow and rosin; a 50-per-cent. rosin soap contains 2 parts tallow and 1 part rosin; a 150-per-cent. rosin soap contains 1 part tallow and 1.5 parts rosin.

A soap properly made of these ingredients and in the proportion of 100 pounds of tallow and 50 pounds of rosin, with not more than 6 per cent. of soda-ash solution added in the crutcher, constitutes the standard high-grade settled rosin soap.

**76. Saponification of Olive, Red, Corn, and Cottonseed Oils.**—Olive, red, corn, and cottonseed oils possess the same general chemical characteristics and behave in the same manner toward saponifying agents.

Olive oil was originally the basis of the soap known to Americans as *Castile soap* and on the continent of Europe as *Marseilles soap*. Pure olive-oil soap is white and very mild in its deterative action. It is composed chiefly, if caustic soda is used to effect saponification, of sodium oleate. It is an excellent ingredient of a toilet-soap base and is especially adapted for use in the textile industry.

Red oil, or commercial oleic acid, being a stronger acid than carbon dioxide, can be saponified to the extent of about 90 per cent. with soda ash. Red-oil soap, sometimes called *oleine soap*, is practically identical in its composition and properties with olive-oil soap, and is therefore equally adapted for the cleansing of textiles.

Cottonseed-oil soap stock, when in a clean condition and as free as possible from coloring matter, is identical in composition with red-oil soap and is adapted for the same

technical uses. In connection with the use of cottonseed-oil soap stock, it should be remembered that it is simply soap, and unless in a very dehydrated condition does not admit of the yield common to all glyceride stock. It is simply an addition used because of its cheapness.

**77. Removal of Stock From Barrels.**—The various animal and vegetable soap stocks are most quickly and conveniently removed from their containers by blowing in live steam. The casks are rolled on a track over the melting trough, shown in Fig. 7, and a swing-joint steam pipe is inserted in the bung hole. The melting trough is made of



FIG. 7

sheet steel, and when the sides serve to support the casks, they are strengthened with a band around the top. The live steam quickly melts the stock, which flows into a storage tank. Here it is left to settle out any foreign matter, or it may be pumped or blown directly to the soap kettle or given a preliminary bleaching.

# MANUFACTURE OF SOAP

(PART 2)

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## PROCESSES OF SOAP MANUFACTURE

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### GENERAL REMARKS

1. As has been shown, soap boiling consists essentially of effecting a chemical reaction between a fatty body and a caustic alkali. The manner of bringing about this combination and the conditions under which the reaction is completed give rise to three general classes of soap-manufacturing processes, namely, boiled, semiboiled, and cold processes, whereby soaps, to which the same descriptive terms may be applied as well, are produced.

*Boiled soaps* are also called *settled soaps* when in process of manufacture they have been subjected to changes by means of which the soap is purified and the glycerine separated.

A *semiboiled* soap is one that has not been subjected to a graining process, but contains all the material added to the kettle. It is also called a *run soap*, which term, however, is without technical significance.

A *cold soap* is one made by the direct combination of the materials in the proportions in which they are to remain in the finished soap, the combination being effected without the aid of heat other than that required to bring the ingredients to the requisite temperature and that evolved by the chemical reaction.



The classification of processes just given is arbitrary and is not based on any essential chemical differences in the processes. The division is more mechanical than chemical and has reference chiefly to the time required, the artificial heat employed, and the mechanical apparatus necessary to a satisfactory operation of the process.

MANUFACTURE OF BOILED OR SETTLED SOAPS

BOILING-ROOM PROCESSES

2. Boiled Soaps.—The boiled soaps are the most important and constitute the class most generally manufactured and used. All household soaps, as well as the base for toilet soaps, are made by this process.

Before discussing in detail the manufacture of soap of this class, the essential features of the process as it is continued

TABLE I  
CHRONOLOGY OF A BOIL OF SETTLED ROSIN SOAP

Chemical, or Physical Change	Description of Process		Time
	Material Added to Kettle	Material Added to and Withdrawn from Kettle	
Saponification, or Stock Change	Straight stock or a mixture of tallow, grease, and cottonseed oil, previously steamed from packages, is pumped from the storage tanks to the soap kettle.	Solid caustic soda of 74° quality is dissolved in water and reduced to 20° Baumé. This lye is kept in storage tanks, from which it is pumped as required.	First Day
	Stock and lye are run into the kettle together and maintained in vigorous ebullition with open steam, before and during saponification, until the greater part of the stock has been added. The completion of saponification and obtaining soap without caustic taste require great care and experience.		
Graining	Either fresh salt, saturated brine (25° Baumé), or dry salt recovered from waste lye in glycerine refining is added in quantity sufficient to bring soap to the proper "grain." Soap made from a suitable admixture of tallow, grease, and cottonseed oil may be considered grained when the waste lye withdrawn contains 7 to 10 per cent. salt.		

TABLE I—(Continued)

Rosin Change		After settling over night, the under lye is withdrawn. This is the stock lye and is richest in glycerine. It is pumped to the glycerine refinery.	Second Day
	Broken rosin is added to the kettle with addition of caustic lye as required. Boiling is continued throughout the day. The soap is kept "open" on the rosin change and grained "close" or "hard." A hard grain at this stage greatly facilitates the dropping of the impurities present in the rosin.	In order to remove the glycerine from the killed stock more completely, the rosin change may be preceded by a "pickle" change; that is, the soap is boiled on brine long enough to keep it grained and settled again over night.	
Strengthening Change		After settling over night, the under lye is withdrawn. This is the rosin lye, and it is pumped to the glycerine refinery.	Third Day
	The contents of the kettle is boiled up and enough alkali is added to keep soap open. Boiling is continued throughout the greater part of the day. This is the most important change of the entire boil. As the alkali is absorbed, more must be added to retain the soap in a grained condition, in which state it is allowed to settle over night. The alkaline treatment received on this change is most effective in removing impurities and the salt retained mechanically from preceding changes.		
Fitting the Soap	After running off the strength lye, steam is turned on. When the soap comes to a boil, water is added and the soap is brought to a proper "finish."		Fourth Day
Settling the Niger	The soap is now left to "drop" the niger and to cool. An average period of 8 days is required to settle out the impurities, although this period varies with the size of the kettle and the season. The strength lye containing considerable alkali is reserved in storage and utilized on the "niger" change of a new boiling.		Fifth to Thirteenth Day
Crutching the Soap	Hot, liquid soap is pumped from the kettle to the crutcher, where it is mixed with sal-soda solution, sodium silicate, borax solution, perfumery, etc. The soap is then dropped into frames and allowed to cool and solidify.		Fourteenth Day

TABLE I—(Continued)

Niger Change	The strength lye is added to the alkaline niger and grease is run in. Boiling is continued vigorously until all strength is exhausted. As the soap at this stage is very dark colored from impurities present in the niger and strengthening lye, it is best to grain sharply to remove them before adding fresh stock. The utilization of the niger method varies greatly and is determined largely by circumstances. It is often transferred to another kettle containing soap on the rosin change, or, as is more commonly the practice, a new boil is started on it.	Three days, usually suffice for soap in frames to arrive at a condition suitable for slabbing and cutting, after which the soap is dried, pressed, wrapped, and boxed.	Fifteenth Day
	The niger lye is withdrawn and pumped to the glycerine refinery. To the grained niger, fresh stock is added and a new boil begun.		Sixteenth Day

throughout the time required for its completion will be considered. There is arranged in Table I what may be called "The Chronology of a Boil of Settled Rosin Soap." In this table is embodied an outline of the most important details of a boil of soap of this character. It is the soap most commonly made in the United States, and the procedure here outlined is the one generally followed.

In an elaboration of the treatment given the soap in the kettle will be discussed the directions and precautions to be observed, from the addition of the soap stock and alkali to the kettle, through the various changes to the transferring of the product to the crutcher and the addition of filling agents, to its final treatment in the drying room and its preparation for shipment.

After the strengthening change, a wash change is often made. This is advisable as a finer and more nearly neutral soap is thus produced. The strong lye from the strengthening change is withdrawn, to be used in some subsequent boiling. The soap is brought to a boil, and water is run in slowly from time to time until an amount nearly equal to the quantity of strong lye withdrawn has been added. The soap is thoroughly boiled, and the lye withdrawn on the following morning should be from 10° to 12° Baumé.

3. The following soap-boiling process is carried out in factories where the maximum yield of glycerine is striven for. A yield of glycerine of from 7 to  $7\frac{1}{2}$  per cent. is possible by following this method.

*First Day.*—A clean kettle, or one containing the niger from a previous boil, is charged with one-third of the stock to be used. Strong caustic is then run in, and the saponification is made as nearly complete as possible. The soap is grained with dry salt or pickle, as may be desired, and is allowed to stand over night. The spent lye is run to the glycerine plant in the morning.

*Second Day.*—The second third of the stock is run in, strong caustic added, and boiling continued for the day. The soap is left weak, as on the previous day, and is grained. The lye is allowed to settle out over night and is run to the glycerine plant in the morning.

*Third Day.*—The last third of the stock is pumped to the kettle, caustic added, and boiling continued as before, the soap being grained in the afternoon and allowed to settle over night, and the lye, as before, being run to the glycerine plant.

*Fourth Day; Rosin Change.*—Rosin is added and saponification is carried on with fresh caustic 20° Baumé in strength. The soap is not grained on salt, but on caustic, just sufficient being used to cause the soap to separate easily from the waste lye on standing over night.

*Fifth Day; Strengthening Change.*—Fresh caustic of 20° Baumé is run in, and the soap is boiled gently all day.

*Sixth Day; Wash Change.*—Water only is used for washing, and, on account of the soap being in a coagulated or granular condition, it removes a great deal of coloring matter and many impurities that were not removed in the two preceding changes. The wash change not only removes considerable of the caustic strength still remaining in the kettle, making it possible to obtain a more nearly neutral soap, but also makes it possible to give the soap a much finer finish. The soap is allowed to stand over night and the waste lye is withdrawn in the morning.

*Seventh Day; Settling, or Finishing, Change.*—The soap is brought to a boil, and water in small amounts is added from time to time until the soap has the proper finish.

4. As will be seen, the lye from the first three changes is left weak and can be run directly to the glycerine plant; while the lye from the next three changes is left strong, and must have this caustic strength removed by being used again on a “killing” change. This strong lye may be used at once by pumping it from one kettle to another, or it may be run to a storage tank for future use.

In order to obtain a complete or nearly complete saponification on the first three changes and still have the lye weak, the process should be carried out by an experienced soap boiler. The need of a chemist to govern the different operations and changes in the boiling room is thus evident.

When thought necessary, a strengthening change may be given the soap before the rosin change. Where low grades of rosin, such as M, N, and K, are used, it may be found necessary to give the soap a rosin wash after the rosin change, in order to remove the excess of color. This operation will take a whole day, and, as on the preceding day, the soap is grained out with strong caustic. By the use of only 5 per cent. more of the better grades of rosin—W W and W G—the difference in cost over M and N will be counterbalanced; also, as 10 per cent. more of the higher grades of rosin can be used and a still better grade of soap be produced, it will readily be seen that the better grades are preferable.

5. *The Soap Kettle.*—The soap kettle is made of sheet steel of a thickness determined by the capacity and is carefully riveted. The kettle is well supported both at the bottom and at the sides. The shape in general use is either cylindrical, or slightly truncated, as shown in Fig. 1, with cone-shaped or dished bottom; or square or rectangular in cross-section, with the bottom either sloping to one side or from all sides toward the center. The circular or square cross-section is largely a matter of personal preference, both

shapes being equally efficient when properly provided with steam coils. Kettles of square cross-section are more economical of space and enable an architect to design a kettle room that can be more easily kept clean. It is necessary to brace square kettles with cross-rods; but with cylindrical

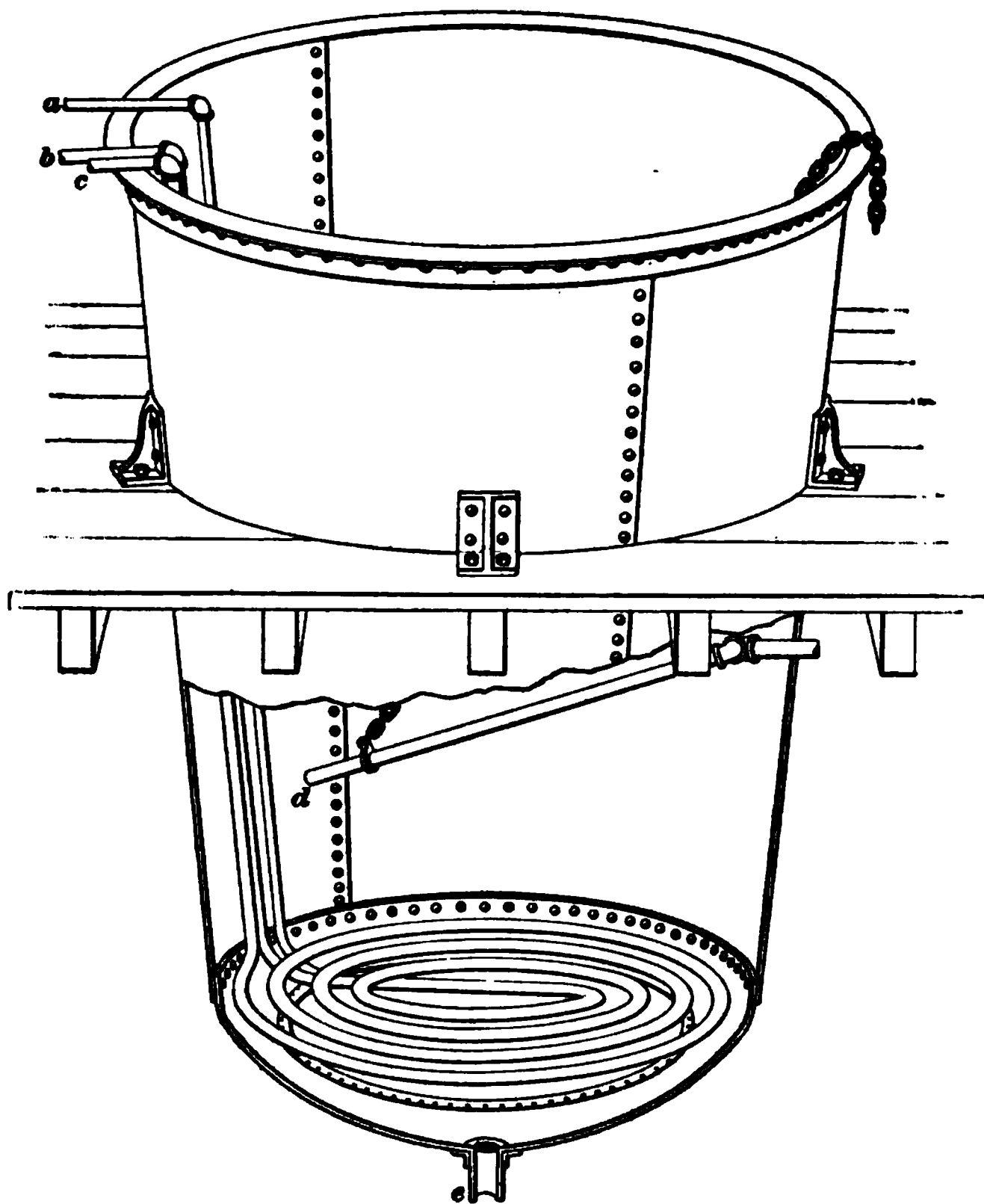


FIG. 1

kettles, this support is not required. The kettle is provided with a swing-joint pipe 3 inches in diameter, through which the liquid soap is removed by pumping. The location of the swing-joint pipe is determined by the dimensions of the kettle and should be at a height that will permit the end of the pipe to touch the lowest point in the bottom of the kettle

while the other, or pivot, end is above the niger line. The swing-joint pipe is shown at *d*, in Figs. 1 and 2.

In a cylindrical kettle, the outlet for removing waste lye is located at the bottom, as shown in Figs. 1 and 2, while in a square kettle, the bottom of which slopes to the side, the lye is removed at the lowest point on the side near the bottom. The waste-lye pipe should not be less than 3 inches

FIG. 2

in diameter, and the opening to it should be covered with a perforated iron plate to serve as a strainer.

6. The arrangement of the steam piping in a soap kettle is a very important matter, as the successful handling of the contents of the kettle depends a great deal on the shape, diameter, and distribution of the coil. The diameter of the

kettle will determine whether one or two open steam coils should be used. With a small kettle, one open steam coil or a crisscross jet in the center will suffice. This crisscross jet is shown at *f*, Fig. 2. With a kettle from 15 to 20 feet in diameter, a second open steam coil around the sides is necessary. The closed steam coil should completely cover the bottom of the kettle. Such a coil, with an open steam coil in the center, is shown in Fig. 3, in which *a* represents the central open steam coil, and *b* and *c*, respectively, the inlet and the outlet of the closed steam coil. In Fig. 1, *a* represents the open steam coil located midway between the top and bottom of the dished part, and *b* and *c*, respectively, the inlet and the outlet of the closed steam coil. The single-pipe coil for closed steam, shown in Figs. 1 and 3, is more expensive than the jointed coil shown in Fig. 2, but is not so liable to leak. The jointed steam coil is cheaper, more quickly and easily installed, and may be enlarged or repaired with only little trouble and expense. The only disadvantage is the greater possibility of leakage. The valves on both the open and closed steam coils should be within easy reach of the soap boiler.

7. The amount of stock that can be killed in a kettle of given capacity varies with the method of

FIG. 3

working. In general terms, it may be stated that 1 cubic foot of space is allowed for every 15 pounds of stock to be saponified, or for every 100 pounds of stock, a capacity of



37½ gallons is required. In Table II are given the dimensions of soap kettles corresponding to the capacities given.

8. Saponification, or the Stock Change.—In this discussion the following combination of stock will be used:

STOCK INGREDIENTS	POUNDS	PERCENTAGE
Tallow . . . . .	11,250	50
Bone stock or grease . . . . .	7,500	33½
Cottonseed oil . . . . .	3,750	16½

TABLE II  
DIMENSIONS AND CAPACITIES OF SOAP KETTLES

Capacity of Kettle Gallons	Diameter at Top Inches	Diameter at Bottom Inches	Depth Inches
150	42	30	36
300	54	42	42
450	60	48	48
600	66	54	48
750	72	66	54
900	66	54	72
1,050	72	60	72
1,200	84	60	72
1,500	90	66	72
1,800	96	72	72
1,875	96	72	78
2,250	96	72	84
2,700	108	84	84
3,000	108	84	96
3,750	108	84	108
4,500	108	84	126
5,000	120	96	120
6,000	126	114	126
7,500	138	114	132
9,000	144	120	144
10,000	150	126	150

This stock will produce a laundry soap of good standard quality and represents the typical stocks employed in American practice in the boiling of the settled rosin soap. The proportions given may be modified according to the prevailing market price for the different ingredients and the quality of soap desired.

9. By referring to Table XIV, *Manufacture of Soap*, Part 1, it will be found that the alkali absorption of the three stocks just mentioned is practically identical, namely, 14 per cent. of chemically pure caustic soda. According to the figures given in Table VI, *Manufacture of Soap*, Part 1, a 20° Baumé caustic-soda lye made from 74-per-cent. caustic contains 13.72 per cent. of sodium hydrate. Caustic-soda lye of 20° Baumé is the density commonly employed, and, as already shown, 74-per-cent. commercial caustic, is about the cheapest grade to buy. It is at once evident that, for all practical purposes, 1 pound of 20 Baumé caustic-soda lye will kill 1 pound of stock. This can be confirmed by referring to Table XV, *Manufacture of Soap*, Part 1, where it will be found that 100 pounds of caustic-soda lye of 20° Baumé made from 74-per-cent. caustic will kill 97.95 pounds of tallow.

With the variation prevailing in the quality of the raw materials, both organic and inorganic, used in the manufacture of soap, calculations cannot be made with accuracy. The amount of alkali theoretically absorbed by a given stock can be ascertained, however, and the quantity thus calculated can be used, but not infrequently will it be found that the soap will contain either a greater or smaller quantity of free alkali or more or less unsaponified matter, and unless a person has practical experience in soap boiling, it is almost certain that the soap will contain both.

Experience gained by working over the soap kettle is the final arbiter. The conscientious man will use the calculations of theory and supplement them with his practical knowledge. It is better to have a small quantity of unkilld stock on the stock change and the alkali completely absorbed than to have an excess of alkali wasted in the stock lye.

**10. Stages of Saponification.**—The saponification of glyceride stock requires three stages for the complete formation of glycerine and the combination of the alkali with the fatty acids. While these stages do not admit of exact definition in the soap kettle, they manifest themselves in certain characteristic conditions, which are familiar to every soap boiler, namely, the emulsion formed on admixture of stock and lye, the pasty mass obtained on continued boiling, and, lastly, the final condition resulting from boiling the pasty mass with an amount of alkali sufficient for complete saponification. By means of chemical formulas, the three successive stages of saponification may be represented graphically:

*Raw Materials:*

Stearin (tallow), $C_{18}H_{36}O_2$	Caustic soda: $3NaOH$
1. Emulsion, $C_{18}H_{35}OH$ ( $C_{18}H_{36}O_2$ )	Soap: $C_{18}H_{35}O \cdot NaO$
	Caustic soda: $2NaOH$
2. Pasty mass, $C_{18}H_{34}(OH)_2$ ( $C_{18}H_{36}O_2$ )	Soap: $2C_{18}H_{34}O \cdot NaO$
	Caustic soda: $NaOH$
3. Glycerine, $C_3H_8(OH)_3$	Soap: $3C_3H_7O \cdot NaO$

**11.** If the piping of the kettle room will permit, all three stocks indicated in Art. 8 may be run in together. However, this is of minor importance, the chief care being to add the stock and alkali simultaneously, with vigorous boiling, and in such proportions that, after saponification has started, the mass can be kept well open until the greater part of the alkali has been added.

While the alkali and stock are being run in together, the mass in the kettle must be kept homogeneous by vigorous agitation or by boiling with live steam. Unless maintained in agitation, too little alkali is liable to cause "bunching," by which is meant local saponification enclosing a mass of unkilld stock. Vigorous boiling will disintegrate and distribute this mass. An excess of alkali grains the mass, thus throwing it, as it were, out of solution, whereby combination is retarded. By the time the total amount of stock has been added, the greater part of the alkali should also be in the

kettle, and boiling is continued, though less vigorously than at the beginning.

Care should be taken to avoid an excess of alkali, and at the end of the change it should be added in small quantities only and not until the strength of the quantity added previously has been absorbed. When the stock has been completely killed, the soap should slide freely from the paddle in large, transparent flakes. A small portion rubbed between the fingers should curl up smooth and dry and without any indication of grease. At this stage the contents of the kettle should boil smoothly, rising in the middle and descending at the sides, the appearance being very characteristic.

On the completion of saponification, the contents of the kettle has become a clear, homogeneous mass, in which is present everything that was added during this stage, namely, soap, glycerine, water, and some sodium chloride, sodium sulphate, and sodium carbonate, which were introduced as impurities with the caustic-soda lye. In addition, the mass contains more or less mucilaginous or albuminous matter that was present as animal tissue in the stock.

**12. Grainng the Soap.**—The separation of soap from water is based on the insolubility of soap in solutions of salts and alkalies. In practice, common salt, either in a dry state or as brine, is used for this purpose. If an excessive quantity of water is present in the kettle, either from condensation of the steam used in boiling or from the use of weak caustic-soda lye, dry salt should be used.

Where open steam is used for boiling, more concentrated solutions, both of caustic soda and common salt, must be used than would be required where closed steam is employed; consequently, the working capacity of the kettle is not only considerably reduced, but the contents is made unsatisfactory to work. Caustic-soda lye of a density of 20° Baumé is entirely too concentrated to saponify tallow. In fact, with caustic lye of such strength, without dilution, saponification of animal and most vegetable soap stock is impracticable. A more convenient and satisfactory way is to prepare con-

centrated caustic lye and to dilute it with water as it is run into the kettle.

**13.** An excessive quantity of water in the kettle manifests itself by frothing, and under such conditions dry salt must be used. The nature of the stock used should also be considered. Tallow alone forms a soap that, at this stage, is of a characteristically firm consistency, although fluid.

Soaps made from cottonseed oil, red oil, olive oil, or rosin are very fluid, and from their consistency would seem to indicate the presence of an excessive quantity of water when such is not the case. Coconut oil makes a very fluid soap, and because of the large amount of salt required for graining, the latter should invariably be added in the dry state.

**14.** The purpose of graining is to separate the soap from the superfluous water with which it is associated, and which, forming the menstruum for the salt, glycerine, impurities in the stock, lye, etc., constitutes the stock lye.

With the contents of the kettle boiling quietly, dry salt or saturated brine is added in small quantities at a time and thoroughly boiled through the soap until a portion taken up on a paddle coagulates or separates so that waste lye runs from it. The waste should be clear, of salty taste, and should not contain free alkali in excess of four-tenths of 1 per cent. This amount of free alkali in waste-soap lye is not perceptible to the taste.

The desired consistency of the grain is a condition arrived at by experience. The use of salt in excess of the amount required to produce this is not only wasteful, but also, if not thoroughly removed in the final settling change, tends to make the soap become fissured, or "cracky," in the frames. The amount of salt added will determine the degree of hydration of the grained soap.

The more concentrated the salt solution in contact with the soap, the less water will be retained by the soap. With an insufficient quantity of salt, the soap will not be withdrawn entirely from solution. With such a condition, the contents of the kettle on cooling will not present a clean line of

demarcation between the soap and the under lye, but there will be an intermediate zone of soft soap. Waste lye withdrawn hot from soap that has been insufficiently grained, will, on cooling, have the consistency of soft soap.

**15.** In boiling soap of the character under discussion the stock lye should not have a greater density than 13° Baumé, and will contain from 7 to 10 per cent. of salt. The soap is sufficiently grained when a waste lye of this character is withdrawn. It has been found by analysis that this is the lowest density that will remove the soap completely from solution; more salt than this quantity is unnecessary and wasteful. The stock lye is the clearest and least discolored, and owing to the high percentage of glycerine present, is the most valuable.

**16.** With the first appearance of a tendency to grain, the quantity of salt added previously should be thoroughly boiled through the soap, and each subsequent addition should be boiled through in the same manner before more is added. When the desired grain has been obtained, the soap is boiled up to the top of the kettle, the steam is turned off, and the contents is allowed to rest until the following morning.

During this time, the soap, by virtue of its lower specific gravity, will have risen to the top and separated completely from the brine. When the waste lye is withdrawn on the following morning, the soap will subside in the kettle an amount equal to the volume occupied by the waste lye. The appearance, shown on the sides of the kettle, should be noted in the effort to obtain uniformity of treatment of successive boils.

**17. Rosin Change.**—In the boiling of settled rosin soap, the rosin change is the one most easily made. After the stock lye has been withdrawn, open and closed steam are turned on, and the greater part of the caustic alkali, which is required to kill the weight of rosin used, is run in. Previous to this operation, the heads and staves of the rosin barrels should be removed and the rosin broken up on bars, between which it falls into a cart or barrow below; it is added to the

kettle through a trap door in the floor immediately above. Where this convenient method is not practicable, the rosin can be broken up on the kettle-room floor and shoveled directly into the kettle. This method, however, entails considerable work in keeping the kettle room clean. Caustic-soda lye of 20° Baumé is also used on this change. The rosin should be broken into pieces not larger than twice the size of the fist. Unless broken into small pieces, the rosin will sink immediately to the bottom of the kettle, where, if the kettle has a cone-shaped bottom and is not adequately provided with steam coils, it melts very slowly and the procedure is unnecessarily prolonged.

On the addition of alkali, as previously noted, the soap is well boiled through simultaneously with the addition of the rosin. Combination ensues quickly. The same care should be taken to insure the fullest absorption of the alkali, with the least amount added in excess to be discharged into the rosin lye.

18. During this change, combination is greatly assisted by keeping the contents of the kettle in a state of partial precipitation by the addition of caustic-soda lye. In the language of the soap boiler, this is termed either "graining the soap with alkali," so called from the consistency that the soap assumes, or "keeping the soap open on alkali," by which is meant not allowing the soap to "close," or to lose its grainy appearance on passing into complete solution. "Opening the soap," therefore, means partly precipitating it by the addition of a body in whose solution it is insoluble.

Toward the end of the change, while the last traces of strength are being absorbed, dry salt can be used, to avoid the possibility of an excess of alkali. This not only allows the contents of the kettle to be worked more easily, but enables a more complete discharge of the coloring matter present in the rosin.

After all the alkali that can be absorbed is added and no traces of it are perceptible in the waste lye, the graining of the soap mass is completed in precisely the same manner

as outlined in Art. 12. The same remarks relative to the stock lye are also directly applicable to the rosin lye.

When the requisite amount of salt has been added to bring the soap mass to the desired grain, the boiling is continued until it rises to the top of the kettle. The contents of the kettle is now allowed to rest until the following morning, during which time the rosin lye separates.

**19.** The rosin lye is nearly always very highly colored, with a depth of color depending largely on the quality of the rosin used. On the stock change, 22,500 pounds of mixed stock was killed. This admixture will carry well one-third its weight, or 7,500 pounds, of rosin—roughly 17 barrels. After the withdrawal of the rosin lye there will remain in the kettle about 45,000 pounds of soap.

**20. Strengthening Change.**—After the rosin lye has been withdrawn, both open and closed steam is turned on. Water is added in just sufficient quantity to close the soap; that is, to transform the contents of the kettle into a homogeneous mass without the separation of soap and lye (see Art. 18). With the soap boiling smoothly, 20° Baumé alkali is added gradually, with sufficient water to dilute it to 8° or 10° Baumé, until the soap is just barely open. With the soap maintained in this condition, by the addition of successive small quantities of caustic lye, as it is absorbed and the soap tends to close, boiling is continued throughout the greater part of the day. After each addition of alkali, the soap will tend to close, both by the absorption of the alkali and by the dilution of the water from the condensed steam. More alkali is then added until the soap is slightly open as before, the procedure being repeated until the attendant is satisfied that the absorption of alkali by the stock is complete. Toward the end of the change, the soap is boiled up to the top of the kettle. At this stage the soap should be just open and have a good sharpness, or alkalinity, although by no means excessive. The soap is now in a good condition for settling. Steam is turned off and the contents of the kettle is allowed to stand until the following morning.



**21.** As noted on the stock and rosin changes, to prevent an excessive quantity of free alkali from being discharged into the waste lye withdrawn from the kettle, a small amount of stock incompletely saponified must be left in the soap. An experienced soap boiler can accomplish this and can likewise produce a soap on these changes containing only a trace of unsaponified stock.

The purpose of the strengthening change is to complete the saponification and to discharge the salt, coloring matter, and other impurities retained mechanically by the soap. No salt is used for graining on this change. The 3 to 6 per cent. of salt commonly present in strengthening lyes represents the amount that has been retained mechanically by the soap and washed from it on this change.

The alkali wash promotes the discharge of the coloring matter, and completing the saponification of the last traces of unkilld stock also assists very materially in the development of the texture desired in the finished product.

**22. Settling the Soap.**—"Fitting" (the term employed in English practice), "finishing," or "settling" the soap consists essentially in thinning the soap to the desired consistency with either weak lye or water. The water may be added during boiling or it may be derived from the steam condensed during this change. The strengthening lye from the preceding change is withdrawn and the soap is boiled up with live steam. Water is added in small quantities at a time until the soap is closed. The open steam valve is partly closed.

The boiling preparatory to settling requires only a comparatively short time, and the change may be finished early in the forenoon. Some free alkali is retained mechanically by the soap after the withdrawal of the strengthening lye. This amount is sufficient to impart a slight sharpness or alkalinity to the settled soap. It is claimed by some manufacturers that the soap should be settled in a perfectly neutral condition; others claim that the best results are obtained with a slight sharpness present.

**23.** The soap is boiled up to the top of the kettle and is then allowed to stand for about 8 days, during which time the contents of the kettle, by virtue of the different specific gravities, resolves itself roughly into two portions, namely, the finished soap, carrying about 30 per cent. of water (this proportion, however, varying with the grain of the finish), and the niger, which carries considerable more water than does the supernatant soap, as well as the impurities and coloring matter settled from it. The settling change is a very important one, for on its proper operation depends the success or failure of the boil of soap.

**24. Niger.**—The niger is the liquor from the settled soap. It contains the impurities and constitutes from 20 to 25 per cent. of the volume of settled soap in the kettle. This proportion varies with the degree of hydration of the finished soap, the length of time allowed for settling, and the temperature of the mass. The more thinly the soap is finished, the larger will be the niger, and the impurities of the finished soap, other things being equal, will be more completely settled into it. Care should be taken not to finish the soap too thinly, for the excessive quantity of water added to the kettle not only makes the finished soap softer, but leaves a large bulk of niger to receive subsequent treatment.

On the other hand, a soap finished too closely, owing to the addition of an insufficient quantity of water, will separate the impurities very incompletely and yield a small niger. Other conditions being satisfactory, the longer the settling period, the more complete will be the separation of impurities, with the formation of a niger of proper volume. If, during this period great attention is not given and the soap is allowed to cool too quickly, which is often the case with a small kettle or with one exposed to the weather, especially in winter, separation of the impurities will be checked by a local or general cooling of the mass. In consequence of which the niger will then remain distributed unequally throughout the soap.

**25.** The settling change is not primarily a purifying change, but provides first for the production of a mass of a certain appearance and consistency, and when this is obtained and the proper conditions just noted are observed, the soap mass separates the impurities, thus forming the niger.

The soap mass is said to be finished "fine" or "coarse," or, respectively, "hard" or "soft," according to its degree of hydration. The condition described as "fine" or "hard" obtains when the soap taken up on the paddle and held in a slanting position falls from it in short, small flakes and cools rather quickly. The condition described as "coarse" or "soft" obtains when the soap falls from the paddle in large flakes and cools less quickly. The appearance and consistency must be learned by actual experience, by personal handling of the material itself.

**26. Filling of Soap.**—The detergency of soap is greatly increased by the addition of certain substances in aqueous solution while the soap is in a fluid state.

*Borax* and *sodium carbonate* are employed, but the use of the former for this purpose is, as a rule, displaced by the cheaper alkaline carbonate.

As all surface water contains mineral salts, chiefly the carbonates and sulphates of lime and magnesium, it is necessary to neutralize these before the soap can exert any cleansing action. Insoluble soaps of lime and magnesium are formed by the combination of soluble soaps and the salts just mentioned, which impart the so-called hardness to surface water.

*Sodium carbonate* is a valuable addition to a soap, as a more economical use of soap is effected by its incorporation, as will be described subsequently. The carbonate effects the neutralization of mineral salts, thus leaving the soap to exert its legitimate cleansing action. The value of sodium carbonate to increase the detergency of soap was early recognized, as was also its property of hardening the soap, thus permitting the incorporation of more water than would be possible without its use.

*Sodium silicate* lends itself readily to incorporation with fluid soap, as it possesses very little detergent power. It is primarily a cheapener and imparts a smooth appearance to the finished soap, which becomes extremely hard on drying.

27. Sodium carbonate and sodium silicate are the chief filling agents. Their use in soap in large or small amounts is determined by the grade desired to be made and gives rise, respectively, to the terms *heavily filled* and *lightly filled*.

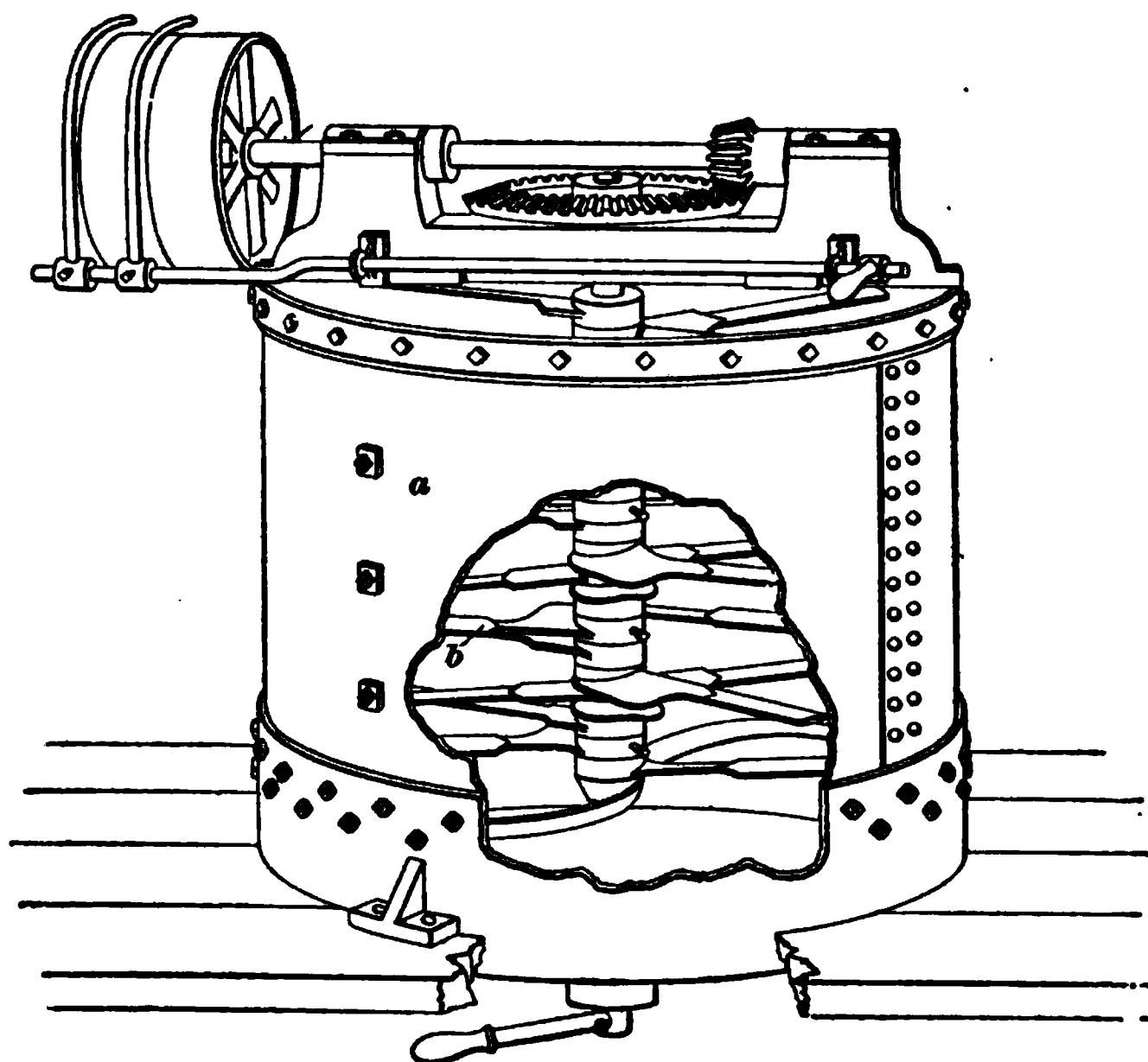


FIG. 4

*Mineral soap stock* is a residuum from petroleum distillation that is frequently used in heavily filled soap. This stock imparts a smooth appearance to such soap, and thus counteracts the tendency of the mineral salts mentioned to grain the soap when added in large amount.

The limit to the use of filling agents is determined by the intelligence of the consumer. The incorporation in soap of filling agents is not, strictly speaking, an adulteration, so

long as the product is sold at a price commensurate with its quality.

**28. Crutching the Soap.**—For the incorporation of filling material into soap, the *bell-driven crutcher* is generally employed. There are three styles of this machine, each of which possesses several points of excellence.

*Style A*, shown in Fig. 4, consists of a cylindrical vessel *a*, in which is mounted a vertical shaft carrying a series of horizontal paddles *b*. These paddles rotate entirely within the

FIG. 5

body of the soap, which remains practically stationary. The blades of the horizontal paddles may be so constructed, however, as to impart an upward movement to the soap. With a crutcher constructed as shown in Fig. 4, it is impossible to incorporate air into the mass of soap, as the mixing is done entirely within the body of the soap.

**29.** The distinguishing feature of the crutcher known as *style B*, shown in Fig. 5, is an inner concentric cylinder *a*, enclosing a broad Archimedean screw *d* mounted on a vertical shaft. Both the outer shell *c* and the concentric cylinder *a*

may be steam-jacketed. This style is more commonly used without the steam jacket.

With this crutcher, the entire mass of soap may be moved from below upwards through the central cylinder by means of the screw *d*, and downwards between the outer shell *e* and the concentric cylinder *a*, or in the reverse direction, according as the belt is advanced or reversed. By filling the crutcher to within 2 inches of the top of the concentric cylinder *a* and rotating the screw *d* rapidly, much air can be

FIG. 6

incorporated into the soap, which is done in the manufacture of floating soap.

30. *Style C*, shown in Fig. 6, is essentially the same as style A. The shaft of this crutcher is horizontal, with blades of varying length mounted in screw-like fashion on it. Soap is pumped into the hopper *a* until the paddles *c* are covered to a depth of 2 inches. The crutcher is then started and run until the soap is crutched. The screw-like motion of the paddles works the contents of the crutcher toward the

outlet *b*, which is closed by the counterpoise *d*. If the soap is not too thick, it will flow freely from the outlet *b*. If too thick, it is necessary to start the crutcher.

Each type of crutcher may be steam-jacketed if desired. In factories that are not equipped with a separate remelter, this feature is essential. The steam-jacketed crutcher can then serve as a remelter. The capacity of a crutcher is that of one frame, namely, 1,200 pounds.

**31. Soap Pumps.**—The liquid soap is transferred to the crutcher by means of a pump. The pumps used vary somewhat in construction, and some of those most generally used will be described.

**32.** In the *Tabor rotary pump*, the working parts of which are shown in Fig. 7, *a* is the shell, or case, of the pump; *b* is the

head that covers the end of the shell; *c* is the piston that carries the valves; *d* are the valves that pass through the piston in the ways *e*, and as the piston revolves, they pass in and out, back and forth through the piston, following the inside lines of the shell. The piston sets tightly against the shell at the point *f*, between the point of suction and dis-

FIG. 7

charge. Rotating the piston creates a vacuum in the suction pipe, and the pump is thus set into operation.

**33.** The *Hersey rotary pump*, shown in Fig. 8, consists essentially of a cone-shaped casting, or piston, *d*, carrying blades, the whole being mounted on the end of a shaft *e*. The piston rotates in a specially shaped case, and when it

turns in the direction indicated by the arrow, suction takes place at the orifice *a* and discharge at *c*. The reverse occurs when the piston is rotated in the opposite direction.

34. The *Johnson rotary pump*, shown in Fig. 9, consists of an outside shell *a*, with suitable parts *b* and *c* for connecting suction and discharge pipes; two side plates, one of which is shown at *d*, with the cam *g*, and inside of all a cir-



FIG. 8

cular casting, or piston, *e*, in which are held the piston heads *f* operated by the cam *g*. As the piston revolves, the cam *g* causes the piston heads *f* to move in and out of their ways, being at their extreme positions as shown in the figure. The block *h* separates the suction and discharge chambers.

35. The rotary type of pump is adapted for a variety of uses in the soap factory. Its simple construction, ease of



operation, and freedom from expensive repairs give it many advantages over the ordinary steam pump. The chief uses for a pump are to transfer stock and caustic lye to the soap kettle, the finished soap to the crutcher, and waste-soap lye to the glycerine refinery. On the discharge side of the pump there should be connected a steam pipe that will serve to blow out and clean the interior of the pump and the discharge pipe after use. As shown in Figs. 7 and 8 the pumps are provided with tight and loose pulleys, on the latter of which the belt may be shifted when the pump is not in use.



FIG. 9

For pumping the soap from the kettle to the crutcher, the pump should be placed below the level of the draw-off pipe in the kettle, and the outlet, or discharge, pipe should be of slightly smaller diameter than the intake pipe. In this way gravity will aid the feed and provide for a steady discharge. The rotary, belt-driven pump represents a great improvement in productive economy over the old-time ladle and bucket as an instrument for transferring soap from vessel to vessel.

## FILLING MATERIALS

**36. Soda Ash.**—The most valuable material to be added to laundry soap is **soda ash**. This material is introduced into the crutcher in the form of a saturated solution. The crutcher room is usually provided with a steam-heated kettle having an agitator for dissolving the soda ash as required. During the afternoon of the day previous to crutching, a quantity of solution sufficient for the entire boil of soap is made up. With a soda-ash kettle of given capacity, the quantity of soda ash and water necessary to produce a solution of the required density is easily ascertained by experience. The mixture is boiled with open steam to a density of 33° Baumé while hot. During the night the impurities in the solution, introduced by the soda ash, will have settled to the bottom and the solution will have cooled to a temperature of about 130° F., with the specific gravity increased to 36° Baumé. A solution lower than this in specific gravity should not be used in filling a soap.

The draw-off pipe should be placed 2 or 3 inches above the bottom of the sal-soda kettle, so as to avoid the removal of the settled impurities. The best location for the kettle, or tank, is on an elevated platform, because the liquor can then flow by gravity into the crutcher in regulated quantities, as desired.

**37.** The quantitative properties of sodium-carbonate solutions above a density of 18° Baumé are determined at a temperature of 30° C. At a temperature of 15° C., solutions of the density shown in Table III (B) will crystallize, forming the hydrated salt,  $Na_2CO_3 \cdot 10H_2O$ , or  $Na_2CO_3 \cdot 10Ag$  as it is more frequently written, commonly known as **sal soda**.

**38.** Concentrated solutions of sodium carbonate, when added in large amounts to any soap and particularly to soap made from soft stock, which, as known, sweats more readily than soap made from firmer stock, will soon cause the soap to effloresce. This is a most disagreeable property and detracts greatly from the appearance of the product. Also,

**TABLE III**  
**SPECIFIC GRAVITIES OF SOLUTIONS OF SODIUM**  
**CARBONATE (LUNGE). (A) AT 15° C.**

Specific Gravity	Degrees Baumé	Degrees Twaddell	Per Cent. $Na_2CO_3$	Per Cent. $Na_2CO_3$ 10 Aq.	1 C. M. Contains Kg.	
					$Na_2CO_3$	$Na_2CO_3$ 10 Aq.
1.007	1	1.4	0.67	1.807	6.8	18.2
1.014	2	2.8	1.33	3.587	13.5	36.4
1.022	3	4.4	2.09	5.637	21.4	57.6
1.029	4	5.8	2.76	7.444	28.4	76.6
1.036	5	7.2	3.43	9.251	35.5	95.8
1.045	6	9.0	4.29	11.570	44.8	120.9
1.052	7	10.4	4.94	13.323	52.0	140.2
1.060	8	12.0	5.71	15.400	60.5	163.2
1.067	9	13.4	6.37	17.180	68.0	183.3
1.075	10	15.0	7.12	19.203	76.5	206.4
1.083	11	16.6	7.88	21.252	85.3	230.2
1.091	12	18.2	8.62	23.248	94.0	253.6
1.100	13	20.0	9.43	25.432	103.7	279.8
1.108	14	21.6	10.19	27.482	112.9	304.5
1.116	15	23.2	10.95	29.532	122.2	329.6
1.125	16	25.0	11.81	31.851	132.9	358.3
1.134	17	26.8	12.61	34.009	143.0	385.7

**(B) AT 80° C.**

Specific Gravity	Degrees Baumé	Per Cent. $Na_2CO_3$	Per Cent. $Na_2CO_3$ 10 Aq.	1 Liter Contains Grams	
				$Na_2CO_3$	$Na_2CO_3$ 10 Aq.
1.308	34	27.97	75.48	365.9	987.4
1.297	33	27.06	73.02	351.0	947.1
1.285	32	26.04	70.28	334.6	902.8
1.274	31	25.11	67.76	319.9	863.2
1.263	30	24.18	65.24	305.4	824.1
1.252	29	23.25	62.73	291.1	785.4
1.241	28	22.29	60.15	276.6	746.3
1.231	27	21.42	57.80	263.7	711.5
1.220	26	20.47	55.29	249.7	673.8
1.210	25	19.61	52.91	237.3	640.3
1.200	24	18.76	50.62	225.1	607.4
1.190	23	17.90	48.31	214.0	577.5
1.180	22	17.04	45.97	201.1	542.6
1.171	21	16.27	43.89	190.5	514.0
1.162	20	15.49	41.79	180.0	485.7
1.152	19	14.64	39.51	168.7	455.2
1.142	18	13.79	37.21	157.5	425.0

when added in greater quantity than the soap can assimilate, the soda ash tends to grain the soap. With heavily filled cheap soaps, this condition represents the limit of the addition; soda ash and other filling agents possessing detergent properties then become adulterants.

**39. Borax.**—The addition of **borax** to soap is desirable, as this material is a mild alkali and possesses all the advantages of soda ash with none of its caustic properties. Owing to the higher cost, its use in soap manufacture is limited; with certain brands, sufficient only is used to justify in a measure the title given to the soap.

**40. Sodium Silicate.**—Next to soda ash, **sodium silicate**, commonly called *water glass* or *soluble glass*, is the most extensively used filling agent. Its consistency lends itself to ready incorporation with the semifluid soap. It possesses detergent power, and when used with due regard to the price of the finished soap, it is a valuable addition to the ordinary household soap.

Sodium silicate is made by fusing pure white sand and soda ash in a reverberatory furnace, such proportions being used that the resulting glass can be expressed by the formula  $Na_2O \cdot 4SiO_2$ . The resulting glass is broken into fragments and introduced into a digester that is already charged with an amount of water to yield a solution of any density desired, and high-pressure steam is then admitted. When solution is complete, the contents of the digester is run into barrels, in which shape it is received by the soap maker.

Sodium silicate is generally used at a density of 40° Baumé, in which condition it has the consistency of thick molasses, is transparent, and hardens quickly on exposure. At ordinary temperatures it will flow readily from the barrel. It must be in a fluid condition when used. In cold weather it may be softened by blowing steam into the barrel. If the head of the barrel is removed and the contents exposed to the air, those varieties deficient in alkaline strength will "jelly," or separate free silicic acid through the displacement

of the latter acid by the stronger carbonic acid of the atmosphere. This may be overcome by stirring up the mass with strong caustic-soda lye, thus effecting a combination of the silicic acid with alkali.

41. When intended for the use of soap makers, the sodium silicate has an average composition as follows: Water, 62.8 per cent.;  $SiO_2$ , 28.7 per cent.;  $Na_2O$ , 8.5 per cent. The more silicic acid the product contains, the more difficultly soluble is it in water. The composition of commercial sodium silicate, as it occurs in solutions of different densities to be used for different purposes, is variable, depending on the proportions of soda ash and silica used in the original charge and on the amount of water in which the fused mass is dissolved in the digester. There is practically no "neutral" silicate; that which is called neutral contains an excess of silicic acid, although it is not acid to litmus.

42. On aging, soap filled with sodium silicate becomes very hard. When well mixed with the soap, a reasonable proportion of sodium silicate greatly improves the appearance and enables a larger quantity of sal soda to be carried without the efflorescence that would soon be produced without its use.

While sodium silicate possesses detergent properties, it is used primarily as a cheapener. By the use of suitable proportions of solutions of soda ash and sodium silicate, the quality of laundry soap is greatly improved. The soap is made more durable from the hardness produced by the crystallization of the salts; also the rapid drying of the soap is retarded.

When used in excess in cheap soap, the salts not only permit the absorption of a larger amount of water than would otherwise be practicable, but also, when used in soap made from soft stock, they impart a firmness that, without their use, would not be possible without having previously transformed the product into a variety of boiled-down soaps.

**43. Miscellaneous Fillers and Adulterants.** Ground quartz, or silica, marble dust, mineral soap stock, a petroleum residuum, starch, and talc may be mentioned as fillers. They are adulterants pure and simple.

**44. Perfuming the Soap.**—With the best grades of laundry soap, it is common practice to add a small amount of either a single essential oil or a mixture of them in order to produce a pleasant and lasting perfume. The quantity added is seldom in excess of  $2\frac{1}{2}$  pounds per frame. The selection of the oil or mixture of oils is best determined by experiment, the object being to choose an oil or mixture of oils that will best counteract the resinous odor inseparable from rosined soaps.

The perfuming of soap, both domestic and laundry, will be discussed at length later.

**45. Crutching the Filler and Perfume Into the Soap.**—During the settling period previously described, the soap will have cooled from that temperature at which it was when in contact with steam to about  $160^{\circ}$  F. The temperature best adapted to crutching depends largely on the character of the stock used in the soap and on the quantity and temperature of the filling material added in the crutcher. The temperature of crutching need not be so high for soap made from soft stock, because of its natural softness, as for soap made from firm stock. Also, in the summer a temperature  $10^{\circ}$  lower than that in the winter is permissible.

If the crutcher is provided with a steam jacket, the soap can be easily kept at any desired temperature. Such devices, however, entail the use of a large amount of steam, and moreover for this purpose are not absolutely essential, but desirable. It is best and of great advantage to add the soda-ash solution at the same temperature as that of the soap, and when prepared as has been previously explained, it will be at the proper temperature when the soap is ready to crutch.

**46.** When ready to crutch, the swing-joint pipe is lowered a short distance below the level of the soap in the kettle and held in place by a chain, as shown in Figs. 2 and 3. The rotary pump is started and the crutcher is filled.

The speed of crutching is best determined by experience. For a soap of the character under discussion, 80 pounds of sal soda is run in and the mass crutched until fairly homogenous. The sodium silicate is then added and crutched in. The perfume is added last, and the soap is crutched until



FIG. 10

a portion removed on a paddle is perfectly homogeneous in texture and smooth in appearance.

Under satisfactory conditions, from 3 to 5 minutes is sufficient to crutch a frame of soap. With completely saponified soap that is pumped into the crutcher at a temperature not exceeding 160° F. in winter and that carries a reasonable amount of filling, no trouble need be experienced in crutching. The primary conditions for satisfactory work are that the stock shall be completely saponified and the soap well

settled. As to the soap being neutral or having a slight sharpness, there is a difference of opinion.

47. At the end of the crutching period, the outlet in the bottom of the crutcher is opened and the contents is emptied into a frame standing on the floor immediately below the crutcher. Where it is possible to operate two crutchers, mounted as shown in Fig. 10, the work is greatly facilitated, as the crutching can proceed in one while the other is being emptied, and vice versa.

The swing-joint pipe in the soap kettle is gradually lowered as the crutching proceeds until the niger is reached. The attendant can always tell when the niger has been reached. When it is thought that nearly all the good soap has been framed, the soap is carefully watched while running into the crutcher, and while it is not always much darker in color, it is always thinner and streaked in appearance.

The kettle charge under discussion consists of 22,500 pounds of glyceride stock to which one-third its weight, or 7,500 pounds, of rosin has been added. The yield for all practical purposes is 50 per cent. Therefore, in the kettle previous to crutching there is 45,000 pounds of finished soap. Considering approximately one-fourth of the total volume of soap for the niger, this kettle charge should yield about 35 frames of soap.

In the crutcher there have been added 80 pounds of soda-ash solution, 20 pounds of silicate of soda, and  $\frac{1}{4}$  pound of perfume, or approximately 8 per cent. of filling to each frame. This increase with the material used is the best practicable maximum, although it may be increased to a greater extent by the use of such adulterants as mineral soap stock, starch, or talc.

48. The crutching of the soap from a 35-frame kettle, if begun promptly in the morning, should be finished by 11 o'clock A. M. After the last frame of soap, free from contamination of niger, has been pumped from the kettle, the pipe leading from the kettle to the crutcher should be blown



out with live steam. The discharge should flow into the kettle.

The swing-joint pipe is now pulled up and secured to the side of the kettle, and steam is turned on. The strengthening lye from another boil is run in and the mixture is well boiled through. During this time, grease is added slowly, and the caustic alkali present in the niger and the strengthening lye is exhausted in the same manner as the stock is killed on the stock change. In this case, however, the soap stock is added to the caustic soda already in the kettle. When the alkali has been completely absorbed, the contents of the kettle is boiled up and grained as previously described. After settling over night, the niger lye is withdrawn and a new boil is begun on the grained niger.

By referring to Table I, it will be observed that on the sixteenth day from the beginning of the boil the kettle is available for a new boil of soap. The distribution of the work over a period of 16 days, as described, is variable, depending on a multitude of conditions, which are different in different factories. The time may be considerably lessened, if the demand for soap warrants it, by continuing the work at night and allowing less time for the settling periods.

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#### FINISHING-ROOM PROCESSES

**49. Framing the Soap.**—The soap frame, shown in Fig. 11, has attained its present shape and size as the result of experience in handling soap at this stage of its manufacture. This frame consists essentially of an uncovered box with removable sheet-steel sides, and with ends of wood or sheet steel set on a wooden bottom, which is mounted on truck wheels. It has a capacity of from 1,000 to 1,200 pounds.

There are various styles manufactured, all with the single aim of producing a box that can be readily put together and taken apart, that will be durable, as light in weight as is consistent with strength, that can be easily moved about, and that will possess the most important qualification—tightness. The dimensions of the frame are variable and are determined,

especially the width, by the size of the bar into which the slabbed soap is to be cut, it being the aim to keep the percentage of scrap at the cutting table as low as possible.

In the frame-room equipment, it is best to have an extra bottom for each frame. The sides of a frame may be removed after the soap has cooled sufficiently to permit this, and then mounted on the extra bottom. This is a most economical method, the usefulness of the frame being doubled, as the original bottom carries the soap through the slabber

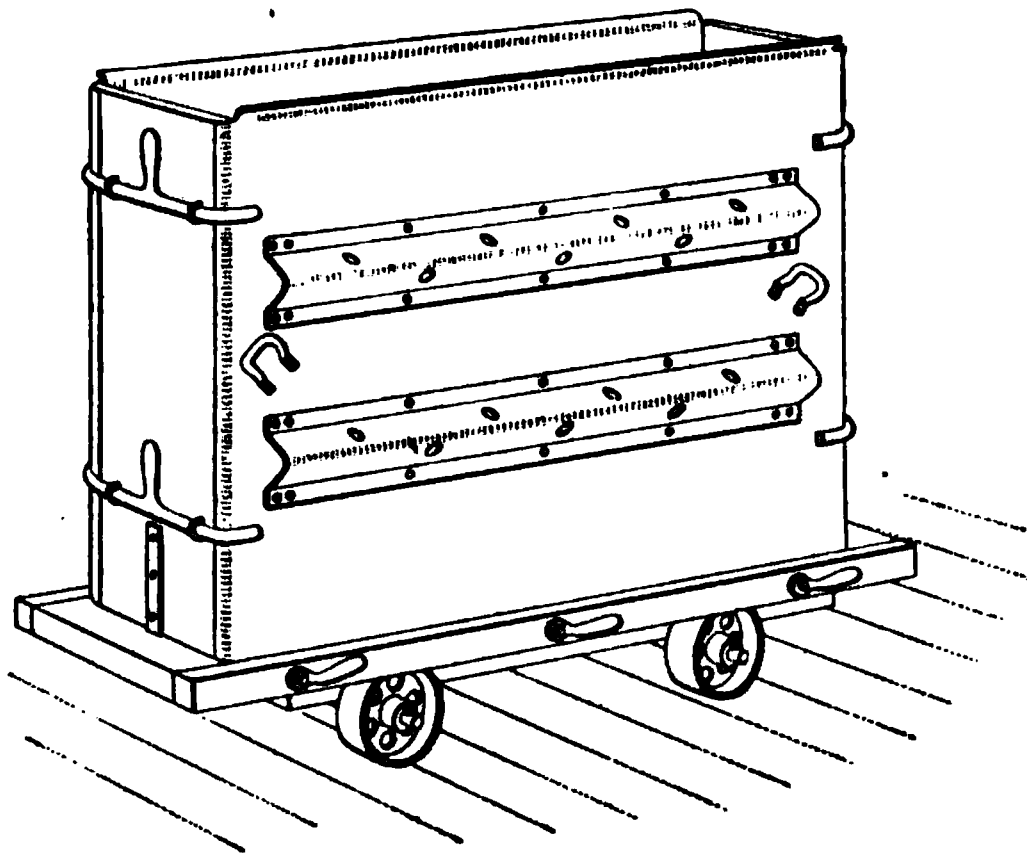


FIG. 11

and to the cutting table, by which time the original sides may be used to enclose a new framing of soap.

50. Previous to crutching, or as it proceeds, a sufficient number of frames are put in readiness. When the crutchers are operated in pairs, an empty frame should stand ready to receive its charge as the preceding one is being filled. The filled frame, with the soap smoothed down into the edges of the frame by means of a short paddle and heaped up longitudinally in the middle, is pushed into its stand in the frame room. Here it is allowed to remain for a varying period, usually from 3 to 5 days, which period is determined by the demands of the factory, the season, the character of the soap, and the temperature at which it was framed.

Before the steam-driven crutcher came into use, the soap was laboriously crutched in the frame with a *hand crutch*.

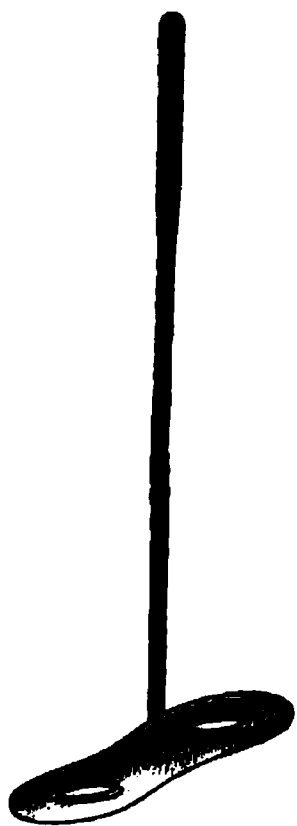


FIG. 12

The hand crutch, shown in Fig. 12, is still in use for soap that may be crutched at too high a temperature, to prevent the filling material from settling to the bottom of the frame; to distribute the material used to produce a mottle; or to distribute the reduction of temperature uniformly throughout the entire mass as cooling proceeds, thus preventing the separation of the softer from the harder soap.

With soap made of the ingredients mentioned in Art. 8, and filled as has been noted, the sides may be removed from the frame on the second day after crutching. After removing the frame sides, the sides of the soap are scraped so as to remove stains and blotches of adhering matter, if present, and the soap is then ready to be slabbed.

**51. Slabbing Machine, or Slabber.**—The device known as the **slabbing machine**, or **slabber**, varies greatly in simplicity and cheapness of mechanical construction. It is a development of the old hand method of drawing a wire in parallel lines longitudinally through the mass of soap. In the machine slabber, whether hand- or steam-driven, the direction of application of the power is reversed, the frame of soap being forced through a series of parallel wires arranged on a framework to the height of the soap to be slabbed. The essential mechanical features of the machine slabber are shown in Fig. 13.

Piano wire is the best for soap cutting. This wire is mounted on the frame head *a* in parallel rows at a distance apart corresponding to the width or height of the unpressed bars of soap. The frame of uncut soap is shown at *b*. By means of a key set in the sides of the frame head, the wires may be tightened or loosened as required. With soap that has stood for some time, it is often necessary to remove,

for a short distance on both ends of the frame, the layer of soap that has become hardened. This permits the wires to enter the soap easily and to separate from it without the abruptness that so often injures the wire; it also obviates undue stretching and breakage of the wires.

**52. Cutting the Soap.**—From the slabber the soap is moved to the cutting table, where it is cut into bars. The fundamental principle of all cutting tables is shown in Fig. 14. A slab is lifted from the pile *a* lying on the frame bottom and is transferred to the table *b*; it is then pushed lengthwise



FIG. 14

through one or two wires held in the cutting head *c*. In this way, the slab is cut into two or three narrower slabs as wide as the single bar of soap is long. These slabs are then cut at right angles by another attendant to dimensions corresponding to the width and thickness of a single bar. The last cutting movement pushes the slabs through the wires in the cutting head *d*, when, as single bars, they are pushed on a rack supported by an extension of the cutting table. Here, by a slight upward and horizontal motion, the individual bars are separated so that air may circulate between them.

The separate racks are placed on a truck until its full quota has been received. The truck load is then taken into the drying room.

**53.** The slabbing and cutting of soap are purely mechanical processes and have for their object the division of the frame of soap into bars. The greatest care to be exercised at these stages is to slab and cut the soap to such dimensions that the amount of waste is reduced to a minimum.



FIG. 14

Freshly cut soap is soft, sticky, and opaque, and if properly crutched should be homogeneous. It contains from 80 to 35 per cent. of water, according to the manner in which the soap was settled and the nature of the additions during crutching. In calculation, it is considered that 100 parts of glyceride soap stock will yield 150 parts of finished soap. The yield is less with rosin alone, and with some stock it may be as great as 157 per cent.

An analysis of pure settled soap at this stage presents the following data:

	PER CENT.
Fatty anhydrides . . . . .	61.80
Combined alkali . . . . .	7.21
Anhydrous soap . . . . .	69.01
Water . . . . .	30.99
Total . . . . .	100.00

**54. Drying the Soap.**—Aside from the processes in the kettle, there is no stage in the manufacture of settled soap that requires greater care in its operation than the treatment received in the drying room. Improperly dried soap, while it may cause no great trouble in the press, is subject to rapid deterioration in appearance, and the influence of this one factor on its ultimate distribution demands that its final treatment in the factory be given the closest attention of the soap manufacturer.

Previous to the introduction of the rapid-drying apparatus, the moisture in the exterior parts of the bar was allowed to evaporate spontaneously. By this method, the drying of soap was an extremely slow and unsatisfactory process, depending largely on atmospheric conditions. A stove in a closed room was a great improvement. This primitive method, with its manifest disadvantages, was succeeded by a system of hot-air circulation by natural draft. Steam heat by simple radiation from pipes was also employed, and with the introduction of forced draft, the elements of the system of drying in use at present were established.

**55. Purpose of Drying Room.**—The purpose of the drying room is to hasten the evaporation of water from the surface of the bar, so that there may be formed a thin crust of comparatively hard soap. This crust serves to retard further evaporation from the interior of the bar and allows the bar to be pressed and stamped without the soap adhering to the dies. Without the formation of this skin of firm soap, pressing and stamping cannot be done properly.

On cutting a bar of soap into halves, this superficial drying becomes plainly evident. The soap when removed from the drying room and after being pressed has a smooth, glossy,

and translucent surface, which condition is in a marked contrast to that observed at the cutting table. During the drying process, from 3 to 5 per cent. of water has been expelled entirely from the surface of the bar, while the interior contains the amount of water originally present, namely, from 30 to 35 per cent. This unequal equilibrium of moisture contents between the exterior and interior parts of the bar partly explains the sweating to which settled soaps are universally susceptible.

This accumulation of moisture does not develop until after the bar is wrapped and packed. If a freshly pressed bar of soap without wrapping were allowed to remain exposed to the atmosphere, it would dry, but would not sweat, assuming, of course, that the atmosphere has not attained the dew point. The moisture in the interior of the bar has passed through the hard surface into the atmosphere, and this process will continue until an equilibrium of moisture contents throughout the bar has been attained.

**56.** With soap wrapped and packed in a box, the conditions are naturally entirely different. The tendency of the moisture to pass from the interior of the bar to the drier surface remains, but further evaporation from the exterior of the bar is checked. Here the moisture accumulates and softens the soap, which in turn adheres to the wrapper. If the soap contains an excessive quantity of mineral salts, these are carried in an aqueous solution to the surface and on subsequent evaporation of the water form an incrustation. Boxed soap in storage should not be subjected to unnatural fluctuations of temperature.

**57. Drying Soap by Forced Ventilation.**—The mechanics of the modern soap-drying room represent more the adoption of a similar process employed in other departments of industry than they do a natural evolution from previous efforts in this particular field. The use of centrifugal fans in the production of artificial draft dates from the 16th century, but it was not until Stevens's experiments in the early part of the 19th century that the devices for

artificial draft resolved themselves into the systems of ventilation known today, namely, the *plenum* and the *vacuum*, or respectively, the *forced* and the *induced*, draft.

In connection with the drying of soap, ventilating fans may be divided into two general classes: the *centrifugal fan*, or *blower*, and the *propeller*, or *disk fan*. The former is more generally confined to ventilation by forced draft and is

FIG. 15

designed primarily for removing air under pressure. Fans of the disk type, shown in Figs. 15 and 16, are not adapted to plenum ventilation, where it is desired to move large volumes of air quickly and under considerable resistance. They find extensive use and are very satisfactory for moving air under slight resistance, as under conditions met with in the ventilation of soap-drying rooms.



58. Both systems of ventilation, the plenum and the vacuum, are used in the drying of soap. The equipment of a drying room under the plenum system comprises, as a rule, a disk fan, two arrangements of which are shown in Figs. 15 and 16. In the arrangement shown in Fig. 16, the fan is operated either by a belt from shafting or by a direct- or belt-connected engine and a sectional heater that consists of steam pipes enclosed in a sheet-iron case *a*, communicating with the discharge of the fan case *b*. Air may be forced through the heater and discharged at the desired temperature into the drying room, or the fan may be interposed and



FIG. 16

air drawn through the heater and then discharged into the drying room. As the results produced are the same in either case, convenience of application will determine the arrangement.

With forced draft, the drying room is best constructed so that heated air enters at one end and leaves at the other, while freshly cut soap is introduced at one side, and, as the drying progresses, is withdrawn at the opposite side. The heater and fan may be placed at opposite ends of the room and the fan used to exhaust the warm and moisture-laden air. This arrangement presents an example of the vacuum

system, or drying by induced draft. The combination of heater and fan shown in Fig. 16 is replaced with advantage by locating the heating coils at one end of the drying room or arranging them in rows throughout the drying room between the trucks of soap. The cheaper and simpler disk fan set in the framework of the wall, as shown in Fig. 15, is, with this arrangement for the drying of soap, equally efficient and satisfactory. The hot-blast drying apparatus shown in Fig. 16, although compact, may occupy valuable space. The exhaust-steam connections with the necessary insulation are simple and easily made.

**59. Heating of the Drying Room.**—By distributing the pipes of the sectional heater throughout the drying room in rows parallel with the trucks of soap and under openings immediately above for the admission of cold air, not only is a greater uniformity of the drying process obtained, but the use of the cheaper disk fan, which is admirably adapted for ventilation by exhaustion, is permitted. Exhaust-steam connections are made through the floor, and by means of suitably placed valves, exhaust steam may be cut off from any section, thus varying the capacity of the drying room at will.

In the drying process, air fulfils two functions: it carries to the moist soap heat necessary for the evaporation of the water and it serves as a vehicle for the removal of the vapor. The capacity of air for heat is very small, its specific heat being only .238, with water as 1; its capacity for vapor depends directly on its temperature and its relation to the dew point, naturally diminishing as the point of saturation is reached. With a rise of temperature, the capacity of air for moisture increases. It is estimated that air at 72° F. has a threefold greater capacity for aqueous vapor than the same volume at 42° F.; at 172° F., its capacity for vapor is more than eighty times as great. Increase of temperature thus means the more rapid formation of vapor, with a much greater increase in the capacity of air for absorbing it.

**60. Requirements of the Drying Room.**—The essential requirements of the heating and ventilating apparatus of

the drying room are that a large volume of air be provided at the required temperature and that this be maintained in rapid circulation. A comparatively low temperature, namely, 90° to 100° F., is productive of the best results. Air maintained at a temperature in excess of 100° F. for a long period causes the soap to undergo an appreciable softening, with

more or less discoloration.

The temperature at which soap will melt depends primarily on the nature of the stock and the proportion of water present. In the drying of "green" soap, it is desirable that the currents of warm air circulate lengthwise of the bar, in order that the largest extent of evaporative surface may be exposed and the drying process thus hastened. The duration of the drying period is easily learned by experience, from the appearance of the bar; it varies from 6 to 12 hours. .

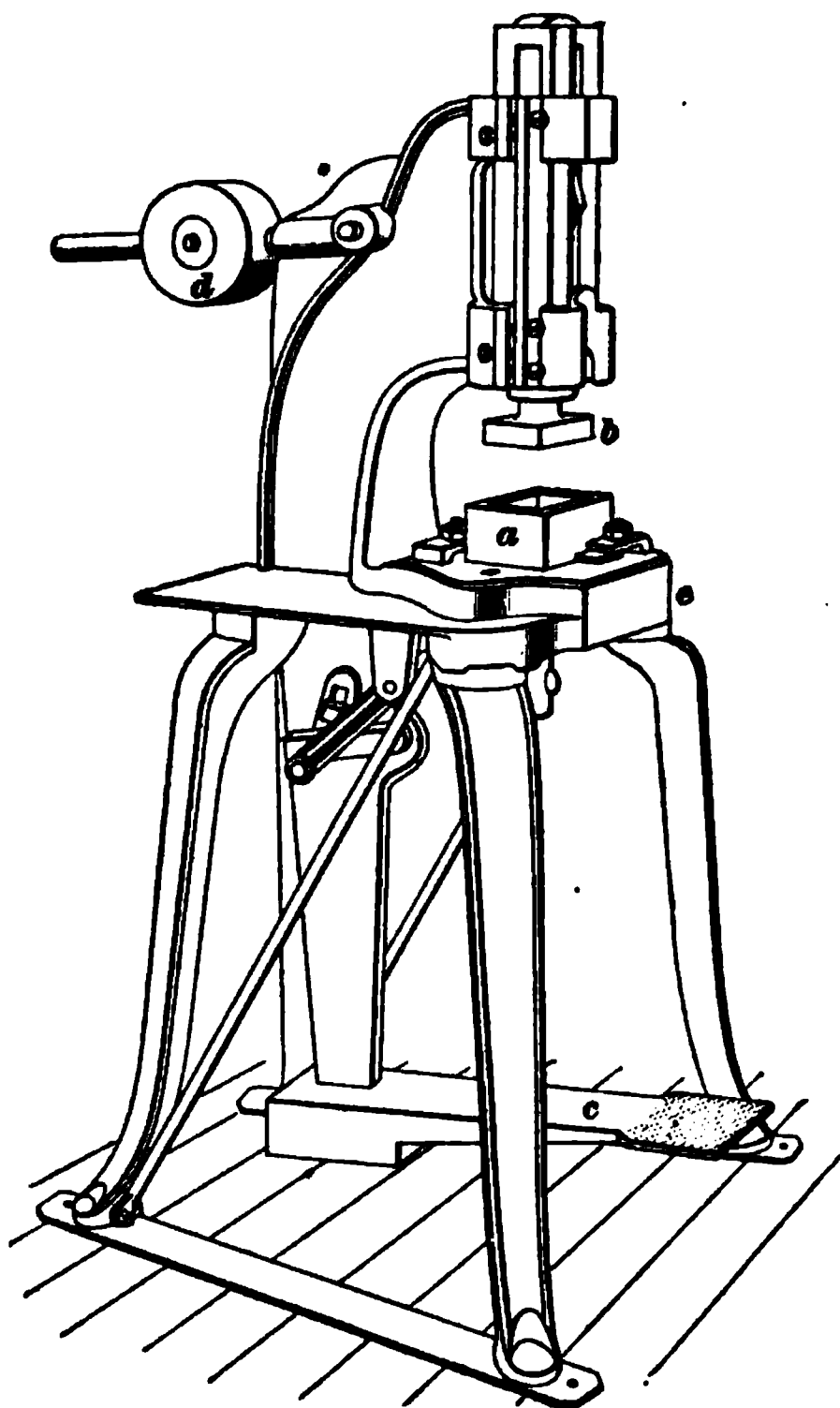


FIG. 17

**61. Pressing of Soap.**—Hard soap was originally sold in the United States in bulk. Later, the soap was cut into bars and packed, with the wrappers in bulk, in a box, the retailer himself wrapping the soap as sold. Under present conditions, however, the freshly cut bar is pressed, stamped, and wrapped.

In Fig. 17 are shown the essential features of a foot-power soap press. This machine is arranged so that the operator can deliver a sudden blow to the cake of soap placed in the die box *a*. The thumb and forefinger of the right hand are used to place the soap in this die box. An operator on a press of this kind will press 30 bars per minute. To prevent soap from adhering to the die *b*, the cake is placed lightly on a bunch of waste saturated with brine or a mixture of vinegar and water that is usually located at the right of the die box *a*. After the blow has been delivered by the right foot placed on the lever *c*, the upper die *b* is lifted by the counterpoise *d*, which also serves to add momentum to the force of the blow, and a lever action lifts the pressed bar out of the die box *a*. The bar is then transferred, by the left hand of the operator, to a table at his left. The foot-power soap press is built in a number of styles, some being partly operated by steam, as shown in Fig. 18.

**62. Steam Foot-Press.**—The steam foot-press, Fig. 18, is provided with a steam cylinder *a*, the piston *b* of which is directly connected with a lever *c* that controls the dies *d* and *e*. A system of valves is arranged at *f* and *g*, from which points, by a slight pressure of the foot on the treadle *h*, steam is admitted to the cylinder *a* and a quick, powerful blow is given to the soap placed over the die box, the lower die *e* of which is elevated as shown. The lever returns instantly, withdrawing the upper die and elevating the lower one, from which the cake of soap is removed by the left hand of the operator. With rapid work, upwards of 1,500 cakes an hour can be pressed on a machine of this type. This kind of press is not used extensively at the present time; it is replaced by more modern machines, which are entirely automatic and give a much higher output.

**63. Automatic Steam-Power Soap Press.**—The belt-driven, automatic soap press is a direct development of the old foot-power press, and arose from a demand for greater rapidity of operation. Several styles are on the market, with a guaranteed capacity of from 60,000 to 75,000 cakes

per day of 10 hours. They are perfectly automatic in their action, require but little attention, and for a factory producing upwards of 400 boxes of soap per day, such a machine is a safe purchase.

The more improved forms admit of interchangeability of the dies, thus permitting the soap manufacturer to use any die that he may have in stock. Thus all the brands of a

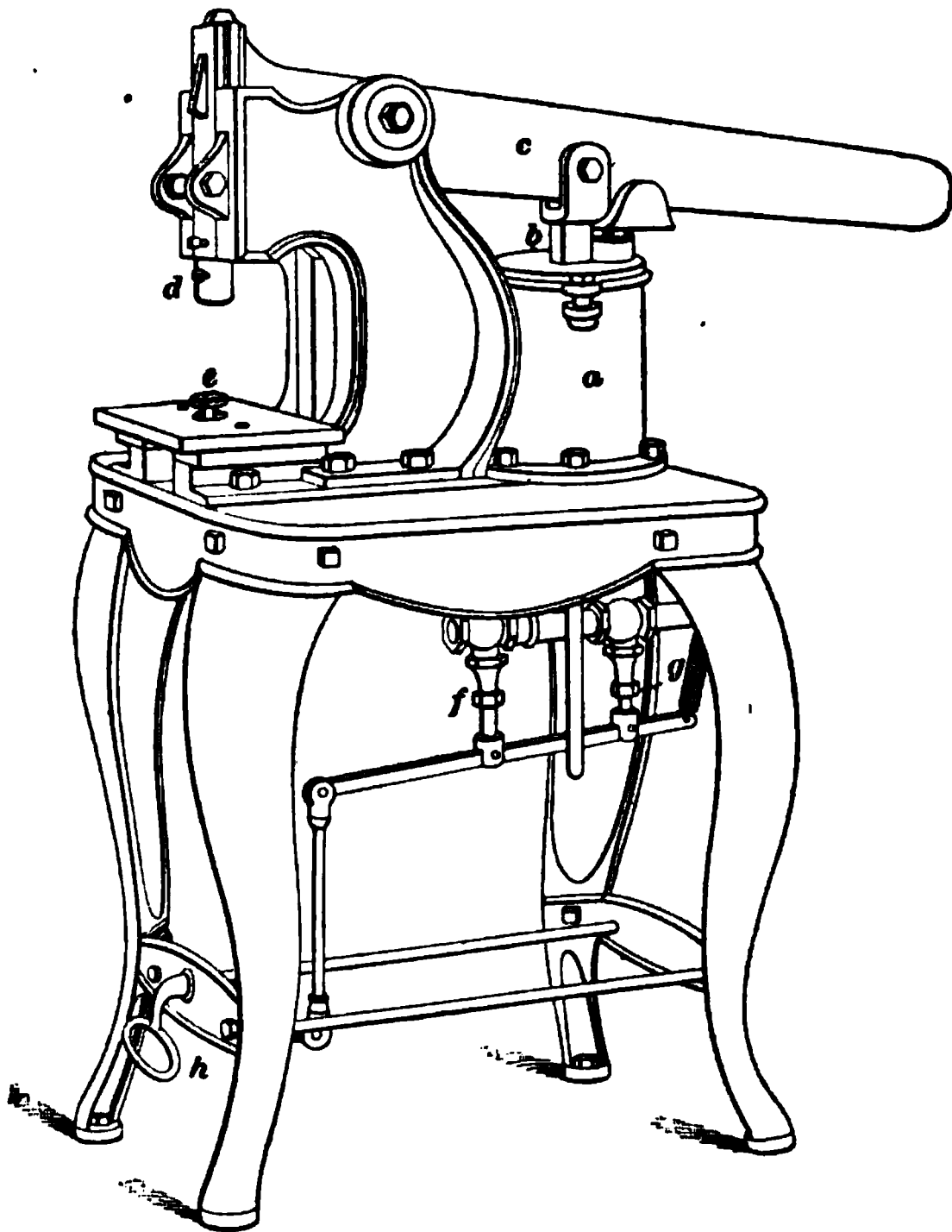


FIG. 18

single factory can be pressed on the same machine, with no longer time required to change the dies than on the old-style foot-press.

**64.** In Fig. 19 is shown one of the latest forms of steam-power soap press. To describe it briefly, power is applied to the pulley *a*, which in turn operates the feeding belt running on the surface of table *b*. This belt carries the cake of

FIG. 19

soap to the drop box *c*, down which it falls between two dies impelled in a horizontal plane at *d*. The cake of soap as it falls down the drop box *c* is caught between the two dies, pressed, and dropped on the belt *e*, which carries the pressed bar to the wrapping bench *f*, where it is wrapped and then packed in boxes.

65. In Fig. 20 is shown a "three-die rotary soap press." This machine consists of double cylinders *a* and *b* placed

FIG. 20

end to end, in which rotate cams that automatically bring together and withdraw horizontally two dies that meet in their corresponding die box, of which three are arranged 120° apart. The dried soap from the racks is placed on the feeding belt *c*, from which each bar is singly moved forwards to the die by a "finger" on the chain belt passing over the pulley *d*, to which power is applied at *e*. A set of dies is shown at *f*. The pressed soap is dropped on the belt running in the box *g* and is conveyed to the wrapping bench.

Among the many advantages possessed by automatic soap presses are chiefly the perfect work, capable, at a maximum speed, of 150 bars per minute; the regulation of the pressure to suit the character of the soap; and the insurance of safety to the operator from loss of fingers. The automatic power press of the capacity stated will do the work of five foot-presses with one-third the labor.

**66. Soap Dies.**—The kind of die to be used is determined by the kind of soap to be pressed. The function of a die is twofold: it forms the yielding mass of soap into a definite shape and imprints on the cake thus formed, in either elevated or sunken letters, or both, usually the brand of the soap and the name of the manufacturer or vender.

FIG. 21

The earliest form is the *hand stamp*, shown in Fig. 21, by means of which the brand or maker's name is impressed on the freshly cut bar.

**67.** The second form is the *box die* shown in Fig. 22. In this form of die, the mold feature is introduced in pressing the soap from above and below in an enclosed space called a *box*. The upper die *a* and the lower die *b* fit closely to the interior of the box *c*. They are so adjusted with the press as to cause their respective downward and upward movement at a separating distance corresponding to the thickness of the pressed bar, which dimension the thickness of the unpressed bar closely approximates. There is thus insured such a distribution of the soap in the mold as to fill every part of it.

FIG. 22



The same box and dies may be used for different brands, by means of detachable name plates. In fitting the box to the bedplate of the soap press shown at *c*, Fig. 17, by means of the shanks shown at *d*, Fig. 22, care should be taken to insure a perfectly vertical motion of the upper and lower dies; otherwise, they will rub against the interior sides of the box, with the result that the accuracy of the die will soon be destroyed.

68. In the molding and stamping of milled soap, dies of a different construction must be used because of the greater firmness of soap of this character. A powerful and sudden blow must be delivered, and the construction of the die must be such as to expel all surplus soap from the cavity, instead of, as in the more yielding laundry soap, forcing this surplus into every part of it.

(a)

FIG. 23

The *pin*, or *shoulder*, *die* is so called from the use of pins and sockets to guide the upper and lower dies, thus preserving their accuracy. The term *shoulder* has reference to the base supporting and receiving the four pegs. As shown in Fig. 23, this third form consists of two dies, (*a*) being the top die and (*b*) the bottom die, without a box, each forming the face and one-half of the cake. The edges *c* and *c'* of the dies strike together, thus forcing out all surplus soap. The guide pins *d*, *d'*, *d''*, and *d'''* of the top die serve to guide it squarely on the bottom die. The shoulders of the bottom die, receiving the guide pins in the corresponding holes *d*, *d'*, *d''*, and *d'''*, bear the force of the blow, and preserve the cutting edges *c* and *c'*. These dies are also made with removable panels, or name plates, thus permitting a number of brands

to be stamped with the same die by inserting a different name plate in the base of the bottom die.

69. The fourth form is a combination of the pin, or shoulder, and box dies, and in addition to possessing the qualities of each, it admits of the pressing of cakes of different thicknesses and weights by virtue of the removable lower die placed in the box. As shown in Fig. 24, *a* is the removable lower die, which is made in varying heights so as to produce a bar of corresponding thickness. It fits into the box *b*, which is fastened by the shanks *c* to the bedplate of

FIG. 24

the presses shown in Figs. 17 and 18. The guide pins of the top die *e* are shown at *d*, and shoulders of the lower die at *f*. The dies are made of gun-metal alloy or rolled brass. They should be substantially made with all moving parts carefully fitted. The engraving should be so executed, with letters or figures of uniform bevel, as to produce in the soap clear-cut and even characters, more especially when these are in relief. The workmanship of the die is shown at once in the appearance of the pressed soap. A good die greatly improves the appearance of an inferior product. Toilet soap is stamped on foot-presses, the automatic press having not as yet proved satisfactory for stamping milled soap.

Fig. 25

**70. Wrapping of Soap.**—The chief care involved in the final process of soap manufacture is neatness. A soap wrapper of average skill will wrap, pack, and nail 40 boxes, of 100 bars each, per day. An experienced wrapper can finish upwards of 50 boxes, while a very rapid worker can often exceed 60 boxes per day.

**71. Plan of a Soap Factory.**—In Fig. 25 is shown a diagrammatic sketch of the essential mechanical appliances of a soap factory. In studying this illustration, the successive processes of soap manufacture may be traced from the lye tank and the stock tank, through the kettle to the crutcher, thence to the frame, to the slabber and the cutting table, and finally through the drying room to the soap press.

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### SEMIBOILED SOAPS

**72.** The term **semibolled**, as applied to soap, refers to a soap that has not been grained, the saponification being completed in one change and the soap strengthened and settled in the following one. As the soap is not grained, in which process glycerine is separated, the kettle will contain, on the completion of the process, all the material that has been added to it. In semiboiled soap, rosin may be used as an ingredient, but the process is generally used only for straight glyceride stock.

As no impurities are removed in the waste lye formed by graining, it is necessary, in order to produce a superior quality of goods, that the stock used be of good grade. This process is often resorted to for the manufacture of the base for cheap toilet soaps. It is used generally for preparing the soap base for soap or washing powders, and is more quickly carried out than is the manufacture of settled soap. The stock can be killed (saponified) in the early forenoon, strengthened after dinner, and pumped to the crutcher, if a filled soap or a soap powder is to be made, or directly into the frame, if intended for toilet soap, on the following morning. If it is desired to save the glycerine and to remove the

impurities as well, the soap may be grained sharply after the stock has been killed, the waste lye withdrawn on the following morning, and the soap carefully strengthened, settled, and pumped from the kettle on the third day.

**73.** The semiboiled process is primarily a cheap method of soap manufacture, with economy in fuel, labor, and time. The best plan, however, is to give the soap a simple purification by graining it sharply, thus prolonging the time consumed in manufacture by one day. By doing so, the volume and depth of color of the niger is greatly reduced.

The semiboiled process is used as well for the manufacture of soft soaps, of which textile soap is a variety, and for green Castile soap made from olive-oil foots. A desired characteristic of the latter soap is the green color arising from the green coloring matter, or chlorophyl, present in the rind and pulp of the fresh olive. This soap is never grained. In graining, the coloring matter would be discharged into the waste lye, with the result that the finished soap would bleach rapidly and unequally on exposure, thus deteriorating in appearance.

**74. Manufacture of Soft Soap.**—As the semiboiled process is used exclusively for the manufacture of soft soap, the boiling of this quality of soap will be discussed in outlining the practical features of the process.

Straight tallow or good grease stock, to which may be added some cottonseed oil, if the price of the latter will permit, is run into the kettle on open steam. According to Table XV, *Manufacture of Soap*, Part 1, for saponifying 10,000 pounds of tallow with caustic-soda lye of a density of 20° Baumé, made from 74-per-cent. caustic, 9,795 pounds will be required. As tallow is a stock that is easily killed and gives well-defined indications of conditions in the kettle, practically all this lye may be added by the time the stock is in, saponification, however, progressing in the meantime. The chief care is to avoid bunching by vigorously boiling the contents of the kettle. Open steam is used throughout the process.

In the manufacture of settled rosin soap, a hard soap was produced; here, however, it is desired to turn out a soft soap made with a soda base. According to an old definition, a soft soap is one in which the alkali used is potash. That definition is obsolete, for the hardness of a soap does not depend primarily on the nature of the alkali present, but on the degree of hydration of the soap. A hard soap can be made of potash and olein, which were the ingredients of the original "Castile" soap.

With settled hard soap, a yield of 150 per cent. is generally obtained; with soft soap, a yield may be obtained varying from 225 to 240 per cent. In fact, the yield may be any amount up to 400 per cent., according to the purpose for which the soap is intended.

75. After the stock has been thoroughly killed, open the soap slightly on caustic (the meaning of *opening* is explained in Art. 18) and boil. This treatment is equivalent to a strengthening change without the intermediate graining. After having boiled quietly on this strength for some time, with an occasional addition of caustic lye as it has been absorbed, add water gradually until the soap closes. There is now in the kettle the soap-maker's 150-per-cent. yield, and the soap is in a condition similar to that of settled soap on the settling change. The degree of hydration is determined either by the specifications of the purchaser or by the price obtained for the product. After the soap has been closed, water is added slowly, care being taken to boil it through the mass thoroughly after each addition, until the soap has been brought to that consistency determined by experience.

A more satisfactory method, and one depending less on the variable and confusing conditions in the soap kettle, is to add the regulated amount of water to the soap in the crutcher. After thoroughly incorporating the addition in the crutcher, the soap is dropped into tight, weighed barrels and allowed to cool. The barrels are then headed and weighed. There is no market in the United States for package-made soft soap; it is sold in bulk to institutions,

for cleansing purposes, and in greater quantities to textile manufacturers.

**76.** When the soap is hydrated in the kettle, the yield is variable, owing to the difficulty of determining the loss of water by evaporation, and in successive boils it may vary several per cent. In the manufacture of soft soap with unmixed stock, as tallow alone, there is not sufficient difference in the amounts of the various glycerides present to produce the "figging" so often desired in a soap of this character. With soft soap made from cottonseed oil, with a small proportion of tallow, the "figged" appearance on cooling may easily be obtained by virtue of the different solidifying points of soaps made from glycerides of different melting points.

Soft soap made from caustic potash will admit of a higher yield within the limits of the quality of the product desired. This arises from the greater combining weight of caustic potash, the molecular weight of caustic potash being 56, while that of caustic soda is 40; also from the fact that a potash soap in a hydrated condition will stand a greater amount of saline filling than will a soda soft soap.

Rosin is used to a great extent in soft soaps, but it should never be present in textile soaps. Linseed oil is extensively used in European practice, and, in fact, may be said to be the chief ingredient. Soft soaps admit of sophistication to a high degree, the principal cheapeners and adulterants being aqueous solutions of sodium silicate, soda ash, and potassium chloride; starch is also largely used.

**77. Calculation of Yield.**—To ascertain the net percentage of yield, simply divide the net weight of soap made by the weight of soap stock used. To arrive at the total yield, the numerator is increased by the weight of the filling material added to the soap in the crutcher or in the kettle.

### COLD-PROCESS SOAP

78. In the discussion of the settled and semiboiled processes of soap manufacture, it was learned that the latter is the more economical process, and for the manufacture of soaps of a certain character, it is the preferable one. The ease with which the soap can be purified by graining and removing the waste lye containing the impurities, indicates how loose is the line of demarcation between the two processes. In the discussion of the manufacture of soap by the cold process, a method that surpasses all others in the economy of every element entering into the cost of production is introduced. The method, however, possesses certain paramount disadvantages, which restrict its use to a very limited field, notwithstanding the large amount of soap of this character that is produced. The mechanical equipment required consists simply of tanks containing the fat, oil, and caustic-soda lye; a crutcher in which the ingredients are mixed; and frames to receive the mixture and in which the chemical reaction of saponification continues, if under favorable conditions, to completion.

With such simple and comparatively inexpensive factory equipment, it will be evident that the proportion of fixed charges in the cost of the product is very small. Experience is the chief and most important asset, and without it, notwithstanding the simplicity of the process, satisfactory results cannot be assured.

79. The term *cold process* is loosely descriptive. The saponification is not conducted in the cold, for the heat generated by chemical combination is considerable. The term has reference chiefly to the fact that heat is not employed as in the two general processes previously described.

The theory of the process is very simple. The essential requirements are that the ingredients taking part in the reaction be intimately mixed. To effect this, the fat or oil must be in a liquid state and the caustic-alkali solutions must be maintained at such a temperature that when the



stock and alkali are mixed, neither will cool the other to stiffness before every particle of the glyceride is brought into contact with the alkali. Even in the daily working of the process, it is a very difficult matter to maintain uniform conditions and to insure the complete absorption of the alkali. As the process is ordinarily practiced, saponification is invariably incomplete, with more or less free fat and free alkali remaining in the finished product. This is the chief disadvantage of the process, and is the one that greatly restricts the use of cold-process soap for toilet purposes.

**80.** To secure satisfactory results in the practical working of the process, it is necessary that the caustic alkali be of high grade, not of lower quality than 76 per cent., and that the glyceride stock be fresh and pure. Without these primary qualifications, good results under no circumstances can be assured; but with them, the prime essentials of satisfactory work are obtained.

Coconut oil, either alone or in admixture with tallow and cottonseed oil, is chiefly used for cold-process soap. The rapid absorption of alkali at a comparatively low temperature, with the production of a smooth, clear soap that will neither crack nor warp on aging and that will admit the incorporation of a large amount of filling, especially adapt this oil as a raw material for soap of this character. With inferior grades of coconut oil, boiling on strong caustic of 36° Baumé with open steam will remove what free fatty acids there are present, and these, with the impurities, will easily settle out. The same preliminary purification is also required for tallow.

The manufacture of cold-process soap received great impetus from the manufacture of high-grade caustic soda; the impurities always present in low-grade caustic interfered greatly with the satisfactory working of the process.

**81. Manufacture of Cold-Process Soap.**—To explain the process in practical detail, the manufacture of cold-process soap from 500 pounds of coconut oil will be discussed. By referring to Table XIV, *Manufacture of Soap*, Part 1, it will be found that coconut oil will absorb about 17.6 per

cent. of chemically pure caustic soda. This amount is equivalent to 18 per cent. of 76-per-cent. commercial caustic; therefore, 90 pounds of caustic soda of this grade will be required for saponification.

A caustic-soda lye of 35° Baumé, made from 76-per-cent. caustic, contains 28.28 per cent. of sodium hydrate. Therefore, to furnish 90 pounds of sodium hydrate, 318 pounds of 35° Baumé caustic lye, made from 76-per-cent. caustic, will be required.

The purified coconut oil at a temperature of from 115° to 120° F. is run into the crutcher, and the latter is put into agitation. The required amount of lye is then run in, and crutching is continued until a portion of the mass removed on a paddle appears clear and homogeneous. This condition can be ascertained only by experience, and under no consideration should the contents be removed from the crutcher until the most thorough mixing possible has been effected. The mixing period need not exceed from 20 to 30 minutes, and with experience the time required is usually less. The mass is then dropped into frames, which are removed and carefully covered with soda-ash bags or other suitable material so as to prevent too rapid cooling. The frames should not be exposed to currents of cold air nor in any way subjected to rapid cooling.

82. There were added in the crutcher 500 pounds of coconut oil and 90 pounds of solid caustic dissolved in 228 pounds of water. This mixture yields a soap that, in so far as hydration is concerned, corresponds to the composition of unfilled settled soap. A yield of practically 63 per cent. has been obtained. By adding tallow and cottonseed oil in suitable proportions, the cost of the soap may be greatly reduced; also, the yield may be increased and the cost greatly reduced by the addition of sodium silicate, soda ash, pearl ash, mineral soap stock, starch, or talc.

All the filling material in cold-process soaps is generally mixed with the lye previous to being added in the crutcher. If it is desired to perfume the soap, the essential oil is added

directly to the mass in the crutcher toward the end of the mixing process.

It should be borne in mind that the more highly filled a cold-process soap is, the more is the process of saponification retarded through the presence of inert material. Cold-process soap will admit of more filling than will settled soap without a corresponding deterioration of appearance on aging.

The substitution of caustic potash for a portion of the caustic soda is desirable, as a clearer, smoother, and milder soap will result.

**83.** In the procedure just described, there has been no interference on the part of the attendant. The ingredients were mixed in the calculated proportions, and the mixture thus obtained was treated mechanically in the hope that the results would be satisfactory. As experience in the operation of the process is acquired, the treatment may be modified according to the judgment of the attendant. In the following procedure the judgment of the manufacturer is called into play.

Add the coconut oil at a temperature of 115° F. to the crutcher and start it slowly; then add gradually the caustic-soda lye, which was prepared at the same temperature. When all the caustic-soda lye has been added, continue crutching at the same or only slightly greater speed for a period of 5 minutes. At the expiration of this period, stop the crutcher and enclose it with a cover and soda-ash bags so as to retain the heat. Allow the mass to stand for an hour and then start the crutcher slowly. If a simple mixer of style A, Fig. 4, is used, the contents should not rise above the level of the topmost horizontal arm; if it does, this portion of the contents will not be thoroughly mixed. With a crutcher of style B, Fig. 5, the contents should not rise above the level of the central cylinder enclosing the screw. With a steam-jacketed crutcher, the process can be more easily controlled through the use of steam, should the temperature fall below that ascertained by experience to be best, namely, 160° F. If at this stage the soap should show an

excessive sharpness to the tongue, a few pounds of coconut oil may be added and crutched in until the soap tastes free from caustic. On the contrary, should the soap, after the maximum heat of the reaction has been evolved, be neutral to the taste, a few pounds of 15° Baumé caustic-soda lye may be added and thoroughly incorporated. After these adverse symptoms have been corrected, start the crutcher at full speed and continue crutching for fully 20 minutes, until the mass rises white and smooth to the top of the crutcher. The perfume is now crutched in and the soap framed.

**84. Manufacture of Cold-Process Soap Directly in the Soap Frame.**—It is possible to make a fairly satisfactory cold-process soap directly in the soap frame, thereby eliminating the crutcher. Elkington has given instructions for the manufacture of cold-process soap by this method according to the formulas given in Table IV.

**TABLE IV**  
**FORMULAS USED IN MAKING COLD-PROCESS SOAP**

Ingredients	Formula No. 1 Pounds	Formula No. 2 Pounds
Tallow . . . . .	75	75
Coconut oil (Ceylon) . . . . .	25	25
Caustic-soda lye (35½° Baumé) made from 74-per-cent. caustic . . . . .	75	70
Silicate of soda, N grade . . . . .	125	100
Pearlash lye, 36° Baumé . . . . .	20	17
Amount of soap produced . . . . .	320	287

**85.** Weigh out the proportions of tallow and coconut oil required for a frame of soap into a tight frame. Weigh out the quantity of caustic-soda lye required into a separate vessel; also weigh out the proportion of silicate of soda needed into another vessel. The pearlash (crude potassium carbonate) solution is then weighed out and mixed with the

silicate of soda. When all is ready for mixing, the temperature of the tallow and coconut oil in the frame should be from 145° to 150° F. in cold weather and from 125° to 130° F. in warm weather. The caustic-soda lye, and silicate-of-soda mixture should be at the normal temperature of the factory.

When the temperature conditions are as just stated, the caustic-soda lye is run alone and quickly into the frame containing the mixed tallow and coconut oil, the mass in the meantime being crutched vigorously from the bottom of the frame. After adding the caustic-soda lye, crutching should be continued until the mass begins to thicken. The mixture of sodium silicate and pearlash lye is now added quickly, with continued crutching.

After the last addition, the mass in the frame will be thinned out considerably and with continued crutching will gradually acquire a thick, creamy consistency. The two hand crutches are now removed, and the frame is carefully covered and allowed to stand without disturbance until the soap is cold. If the soap is to be perfumed, the essential oil is stirred in with the silicate-of-soda mixture and added with it. If the frame must be moved from where the soap is made, move it quickly before the silicate-of-soda mixture is added; then add this mixture at once and finish the soap as directed. The cold process is primarily a quick process, the tardy addition of any ingredient being sufficient to mar the results.

For a 1,000-pound frame, the caustic-soda lye must be run into the soap stock in from 90 to 120 seconds. The addition of the silicate-of-soda mixture should also not require more time than this. Two crutches (see Fig. 12) should be used, the work carried on quickly, and the bottom of the frame reached at each stroke. With satisfactory conditions of temperature, the time required in preparing a frame of cold-process soap as just outlined should not exceed from 12 to 16 minutes. Care should be taken not to crutch the mass too long. To insure a smooth soap, crutching should be stopped as soon as a mark made on the surface of the soap will remain, and under no circumstances should the frame be disturbed until the contents is cold. With good, firm tallow,

cottonseed oil may be substituted for it to the extent of from 30 to 50 per cent., and less if the tallow is softer. With soft stock, more time will be required for cooling.

**86.** The apparatus used in cold-soap manufacture admits of very convenient arrangement. The soap-stock and alkali tanks should be placed on an elevation above the crutcher and should be provided with closed steam coils for heating the contents to the required temperatures.

Successful operation can only be carried out by weighing the stock and the alkali. If two scales are available, tanks sufficiently large to hold stock for five frames may be used, the weight each time being taken by difference. The stock and alkali are run from the storage tanks to the weighing tanks, and from there to the crutcher. If only one scale is available, the tank need be only large enough to charge one frame, the stock being weighed out and emptied into the crutcher, and after this the alkali and filler, if any is used. In this manner, mistakes in the weights of the material used may be avoided.

**87.** In summing up the advantages and disadvantages of the cold process, it may be stated that the soap is simply, easily, and quickly made, with but little outlay required for plant and labor. It admits of a greater yield than that furnished by any other process for the manufacture of hard soap. A well-made cold-process soap has not only a better appearance than a boiled soap, but retains its good appearance longer. It admits of a greater degree of filling than does a settled soap. The process differs greatly from the boiled processes in one important particular, namely, that small quantities can be made at a time. The process is used extensively for cheap toilet soaps, in some instances for laundry soap, and almost entirely in the manufacture of chipped soap that is sold to laundries.

As ordinarily practiced, the process does not admit of complete saponification, as does the boiled processes, the soap invariably containing, according, to the care and experience

used in its manufacture, greater or smaller amounts of free caustic alkali and uncombined fat or oil. Rancidity soon develops from the presence of uncombined oil. This is the chief, and practically the only, disadvantage of the cold process.

# MANUFACTURE OF SOAP

(PART 3)

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## REMELTING OF SOAP

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### PURPOSE OF REMELTING

1. Soap scraps result from various sources, which may be enumerated in the order of their occurrence, namely, frames of soap that have cracked or fissured or for any cause are not suitable, either in whole or in part, for slabbing and cutting; scrapings from frame bottoms; defective bars and trimmings from the cutting table; spoiled bars from the soap press; and unsatisfactory boxed soap returned by the trade. Such soap contains its proportion of the filling added in the crutcher, and if the soap were returned directly to the soap kettle, this filling would be lost in the waste lye. The function of the remelter is to remelt these scraps, and when melted, the soap is crutched and framed as before.

Some perfume and usually a small quantity of soda-ash solution are generally added to the remelted soap in the crutcher. The texture of remelted soap when cut and pressed differs from that of freshly pressed soap in being less clear.

When possible, it is always best to place the remelter above the crutchers and not to crutch the remelted soap alone, but to mix it with fresh soap coming from the kettle. The amount of soap, or scrap, to be remelted is usually equal to about 10 per cent. of the output of the factory, so that if frames having a capacity of 1,200 pounds are used, each



crutcher should have 120 pounds of remelted soap added to it. By following this method, a uniform product is possible—one feature of the soap trade that is very essential in order to insure a successful and profitable business.

**2. Remelters.**—As shown in Fig. 1, a remelter consists of a sheet-steel tank with a system of closed steam pipes *b* arranged vertically inside and also a system of closed steam pipes *c* arranged horizontally on the bottom and a

Fig. 1

short distance above the outlet *e*, the pipes *c* being connected with pipes *b*. A coarse wire netting *d* serves as a strainer; it is placed below the steam coils *c* and above the open steam jet *f*. The pipe *i* carries steam to the upright system *b*; the exhaust pipe *j* carries the water of condensation from the horizontal system *c*; and the live-steam pipe *k* supplies the steam jet *f*. The remelter is usually covered with insulating material, to retain the heat, and is surmounted by a wooden casing so as to receive the soap on the floor above.

The steam pipes are so arranged as to distribute the heat uniformly throughout the mass and to interfere least with the flow of the melted soap, by gravity, from the bottom of the remelter.

3. When sufficient scrap for several frames has accumulated in the remelter, steam is admitted into the closed coils and the adjacent soap is melted. Live steam is then introduced for a period of 10 minutes in addition to the

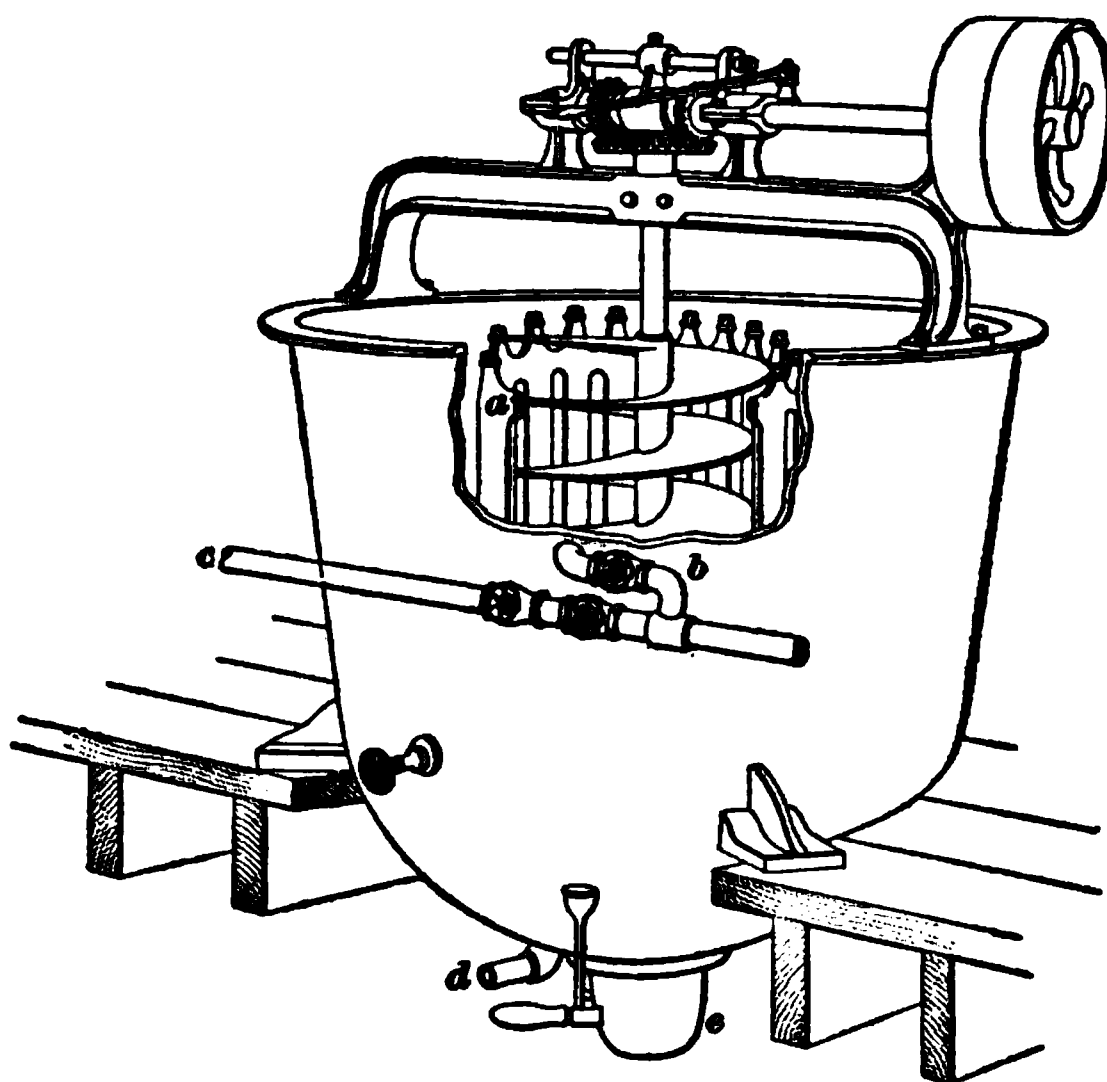


FIG. 2

closed steam. At the expiration of this period, the remelted soap should flow freely from the outlet. The live steam is now turned off. When sufficient of the mass has melted to charge the crutcher, which is usually placed below the remelter in factories where a separate remelter is used, framing is begun and continued as fast as the soap melts. The remelted soap withdrawn is replaced by unmelted soap, which sinks by gravity from the wooden casing surmounting the remelting tank. The remelter is an indispensable part of the factory equipment.

**4. Remelting Crutcher.**—When the size of the factory does not warrant the installation of a separate remelter, as shown in Fig. 1, the remelter may be combined with the crutcher, as shown in Fig. 2. The **remelting crutcher**, as this device is called, is simply a crutcher of style B, shown in Fig. 5, *Manufacture of Soap*, Part 2, in which the inner concentric cylinder is replaced by vertical, closed steam pipes surrounding the screw. Steam is admitted into the vertical, closed steam pipes *a* through the valve *b*. Live steam is introduced at *c*, and the water of condensation is withdrawn from the closed steam pipes at *d*. The outlet of the crutcher is at *e*. The remelting of soap in this device is carried on practically the same as with the regular remelter. Soap scrap may be introduced by gravity from a receptacle placed above the crutcher.

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## MANUFACTURE OF TOILET SOAP

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### MILLED-PROCESS SOAP

**5.** The manufacture of toilet soap requires the installation of expensive machinery and a greater degree of skill than is necessary in the manufacture of laundry soap. Not only the cost of plant and the superior skill required in manufacture, but the experience and ability required in marketing the product, confine its manufacture to a comparatively limited number of plants. The manufacture of toilet soap in the United States dates from 1844, at which time a Frenchman, Jules Haul, made soap of this character with very primitive apparatus, in Philadelphia. The French were the original manufacturers of toilet soap, and with their experience and prestige as perfumers, have been able to maintain their reputation for superior products of this kind to the present day. Since the original manufacture of toilet soap in the United States, just noted, American skill and experience, together with the superior mechanical appliances employed, have so far advanced that the toilet soap

produced in this country is equal to that produced elsewhere in the world.

**6.** Although toilet soap can be made by any of the three processes previously described, the term generally has reference to what is called a **milled soap**, meaning by this a soap that, after having been partly dehydrated, is kneaded into films of dough-like consistency in a machine called a *mill*. The soap is then compressed into an elongated bar, which is cut into sections and pressed into separate cakes.

By this process of manufacture it is possible to combine the finest style and finish with superior quality and durability. Owing to the partial dehydration to which the toilet-soap base has been subjected, its milling, and the subsequent compression in the plodder, soap manufactured in this manner is the most economical for toilet purposes.

**7. Toilet-Soap Base.**—The manufacture of toilet soap requires first the manufacture of what is commonly called the **toilet-soap base**. This may be either a well-made settled soap, a semiboiled soap, or a cold-process soap. The principal requirements of a good toilet-soap base are that it be made from fresh material of good quality, be free from impurities, completely saponified, perfectly neutral, and of a good, tough grain. In large establishments, the manufacture of the toilet-soap base is usually entrusted to one man having special skill in the boiling of soap for this purpose. The nature of the stock used is very important.

Good, fresh tallow, with the characteristic shortness of grain of the soap made from it, softened by the addition of suitable proportions of cottonseed oil, and smoothed with a proportion of coconut oil, will make a first-class toilet-soap base. The formulas of the toilet-soap base vary greatly. Castor oil and lard may be used to make the soap milder and to admit of a finer finish in the pressed bar. In the manufacture of cheap toilet soap—what is known in the trade as five-and-ten-cent goods—not only is material of inferior quality used, but also adulterants well known to the toilet-soap miller, to which is added a fragrant and lasting per-

fume. Palm oil forms an excellent ingredient of the toilet-soap base, the natural odor of the oil harmonizing well with the perfuming material.

In the boiling of the toilet-soap base, the greatest care lies in completely saponifying the stock. In the use of coconut and cottonseed oils, this is very important, for there are no oils used by the soap maker that are more liable to become rancid, especially when present as unsaponified stock in the finished soap, the rancidity being invariably betrayed by the odor on the hands after using.

**8. Boiling the Toilet-Soap Base.**—The manufacture of the toilet-soap base does not differ essentially from the manufacture of settled rosin soap. Too much stress cannot be laid on the facts that the stock must be pure and fresh, the kettle and all appurtenances scrupulously clean, and that completeness of saponification must be insured. The stock change is effected as previously described, care being taken to kill the stock thoroughly, even though the stock lye may contain an excess of caustic alkali. A slight strength is desirable, as it is believed that the texture of the soap is thereby improved. After graining and settling the waste lye, the latter is run off. The soap is then boiled, or strengthened, with the addition of weak caustic lye, after which it is grained sharply with undiluted caustic lye. This strength lye is withdrawn and held in storage for use in inferior grades of soap. The soap is now boiled up with live steam, and water is carefully added until the soap shows a characteristic flat grain and is all but closed. The soap is now allowed to settle, as on the settling change in the manufacture of settled rosin soap. It is believed that the more completely settled a toilet-soap base is, the better adapted it is for milling, due to the separation of salts and impurities that tend to form the niger. The more thoroughly these are removed, the less liable is the soap to come from the plodder in a cracked condition. At the expiration of the settling period, the soap, if no filler is added, is pumped directly into frames.

9. The nature of the process to be used in the preparation of the toilet-soap base and the care to be taken in the operation are determined by the quality of the product desired. For cheap, milled soaps, a base made by the cold process may be used, but more generally one made by the semiboiled process is used. With the latter process, the soap should be carefully settled; then the niger, if stock of good quality is used, can be incorporated in a succeeding boil or, preferably, added to a kettle charge for laundry soap. The soap is framed in the regular way and when cold is ready for cutting.

In the manufacture of hard soap, free from filling, whether by the settled, the semiboiled, or the cold process, the yield is commonly estimated as 50 per cent. This, therefore, gives the toilet-soap base, by whatever process it is manufactured, a water content varying from 30

FIG. 3

to 33 per cent. To insure a satisfactory product on milling, this percentage of water must be reduced about 50 per cent. With settled soap for laundry purposes, the water content was reduced from 3 to 5 per cent., just sufficient to permit a good finish on pressing and stamping.

10. **Preparation of the Toilet-Soap Base for Milling.** In preparing the toilet-soap base for milling, the frame of soap is cut into long bars of such dimensions that the preliminary

drying is effected in the quickest manner. At this stage it is merely desired to dry the soap, so that it can be reduced to chips in a cleanly manner. The superficially dried bars of soap are laid lengthwise in the feed-box *a* of the automatic chipper shown in Fig. 3, when they fall by gravity against the knives set in the radial slits *b*, two of which are shown. The soap can be cut into chips of any desired thickness by adjusting the knives at varying distances above the surface of the disk *d*, which is rotated by a pulley on the shaft *c*. The chips are collected on the opposite side of the machine and spread on the bottoms of trays. These are then transferred to the



FIG. 4

drying room, where they are allowed to remain until the water content has been reduced to that degree permitting the most satisfactory treatment in the milling machine.

11. A very convenient arrangement for the drying of toilet-soap chips is shown in Fig. 4. Air is drawn through the sectional heater *a* in the direction indicated by the arrows by means of the centrifugal fan, or blower, *b*, forced through the casing of drawers, and expelled at the stack. In the illustration the casing is partly broken away so as to show the location of the blower. The degree of dehydration is variable, depending on the quality of the product desired.

If cheapening material is to be added in the mill, its capacity for moisture demands that the chips be not too dry, or the soap will come from the plodder in a cracked condition. Again, with unfilled toilet soap, the consistency of the mass may be varied at will by suitable treatment during the milling process. If the soap works too dry in the mill, either softer soap of the same quality or some water may be added, according to the judgment of the miller.

The continuation of the drying process is best determined by experience. For goods of superior quality, the chips are sufficiently dry when the water content has been reduced

FIG. 5

from 30 or 33 per cent. to 15 or 18 per cent. The chips are now ready for the milling process.

**12. Toilet-Soap Mill.**—The toilet-soap mill, shown in Fig. 5, consists of a hopper *a*, in which the soap to be milled is placed, set on rolls *b* and *c* of a series of granite rolls *b*, *c*, *d*, and *e*. These rolls vary from three to five in number. They are carried on heavy steel shafts, forming the core of the roll, and are mounted in the most improved machines one above the other at an angle of 45°. Quincy granite, with a smooth and true finish, is generally used for the rolls, which vary in diameter from 8 to 18 inches, and in length from



16 to 24 inches or longer, as desired. The capacity of the mill is rated by the manufacturer according to the amount of soap milled per hour, varying from 80 to 250 pounds for the roll dimensions just mentioned. The roll *c*, Fig. 5, is supported in stationary journals. The intervening distances between adjoining rolls may be varied at will by means of setscrews on both sides of the mill. In the illustration, the setscrews on one side are shown at *f*, *g*, and *h*. The rolls rotate on their shafts in the directions indicated by the arrows.

**13. Milling the Toilet-Soap Base.**—When the chips are dried suitably and have the right “feel” when taken up by the handful, the amount required for a charge is introduced into the hopper and passed through the mill until reduced to a fairly homogeneous mass. One milling should suffice for this initial reduction.

During this preliminary milling, the distance between the rolls should be greater than at later stages in the milling process, owing to the coarseness of the material worked. During milling, the chips pass down between rolls *b* and *c*, Fig. 5, up between rolls *c* and *d*, and down between rolls *d* and *e*. Then, in the condition of a thin, translucent film, they are removed by scrapers from the last roll and returned to the hopper, if desired, for another milling.

When of proper consistency, the soap is collected in a box or trough, where the perfume and coloring matter in proportions based on the weight of the charge of soap delivered to the mill is added. If the perfume and coloring matter are in a dry state, it may be simply dusted on the soap in the mill. If liquid, they must be added to the shreds of soap resulting from the first milling and allowed to percolate through, yet not flow from, the mass. The soap is then transferred to the hopper and worked through the mill to the satisfaction of the attendant.

For cheap goods, three or four millings may suffice; for superior goods, or to produce the best possible texture in goods of any quality, seven or eight millings are required.

After the milling process, the shreds of soap should be perfectly homogeneous, with the perfume and coloring matter, if any of the latter is used, thoroughly worked through.

**14. Plodding Toilet Soap.**—After satisfactory results have been obtained in the milling process, the soap is ready for the *plodder*. The soap as it comes from the mill is in thin, translucent laminæ. The function of the plodder is to compress this soap into a compact mass, which is expelled from the plodder in the form of an elongated bar. This bar is then cut into cakes of dimensions adapting them to the mold and die of the soap press.

**15. Plodders.**—The earliest form of plodder was the naked hands, which molded the mass that was crudely kneaded with mortar and pestle into a globular or oblong bar.

The earliest form of machine plodder was a cylinder enclosing a screw, by means of which the soap that was fed into the cylinder at one end and above the screw was compressed. This is essentially the construction of the modern plodder. The improvements on this early form consist chiefly in an increase and a more scientific distribution of the weight of the machine, and in the substitution of steam as the source of power, thus permitting a greater compressive force to be applied to the soap. These mechanical improvements in the plodder have enabled toilet-soap manufacturers to produce a more compact, a more durable, and a more handsome piece of soap.

**16.** In the plodder shown in Fig. 6, *a* is the hopper into which the soap is placed; *b* is the case enclosing the horizontal screw compressor impelled by power applied by means of a belt to the pulley *c*; *d* is a concentric hollow casing enveloping the nozzle of the plodder, and is filled with water added at *g* and maintained at a definite temperature. The cake former *e* is heated by a gas flame applied at *f*, and it is screwed to the nozzle through which the elongated bar of compressed soap is forced. A sectional connection *h* of the screw case provides for the ready

examination of the interior of the case. So long as soap is added to the hopper, the action of the plodder is continuous.

Plodders may be divided into two classes, according to the mode of applying the power, namely, the *hydraulic* and the *steam plodder*. With the former, the output per day does not exceed 1,000 to 1,200 pounds of soap; with the latter, the output in the same length of time is much greater. The hydraulic plodder is being displaced by the steam-driven plodder, with its greater rapidity of operation,

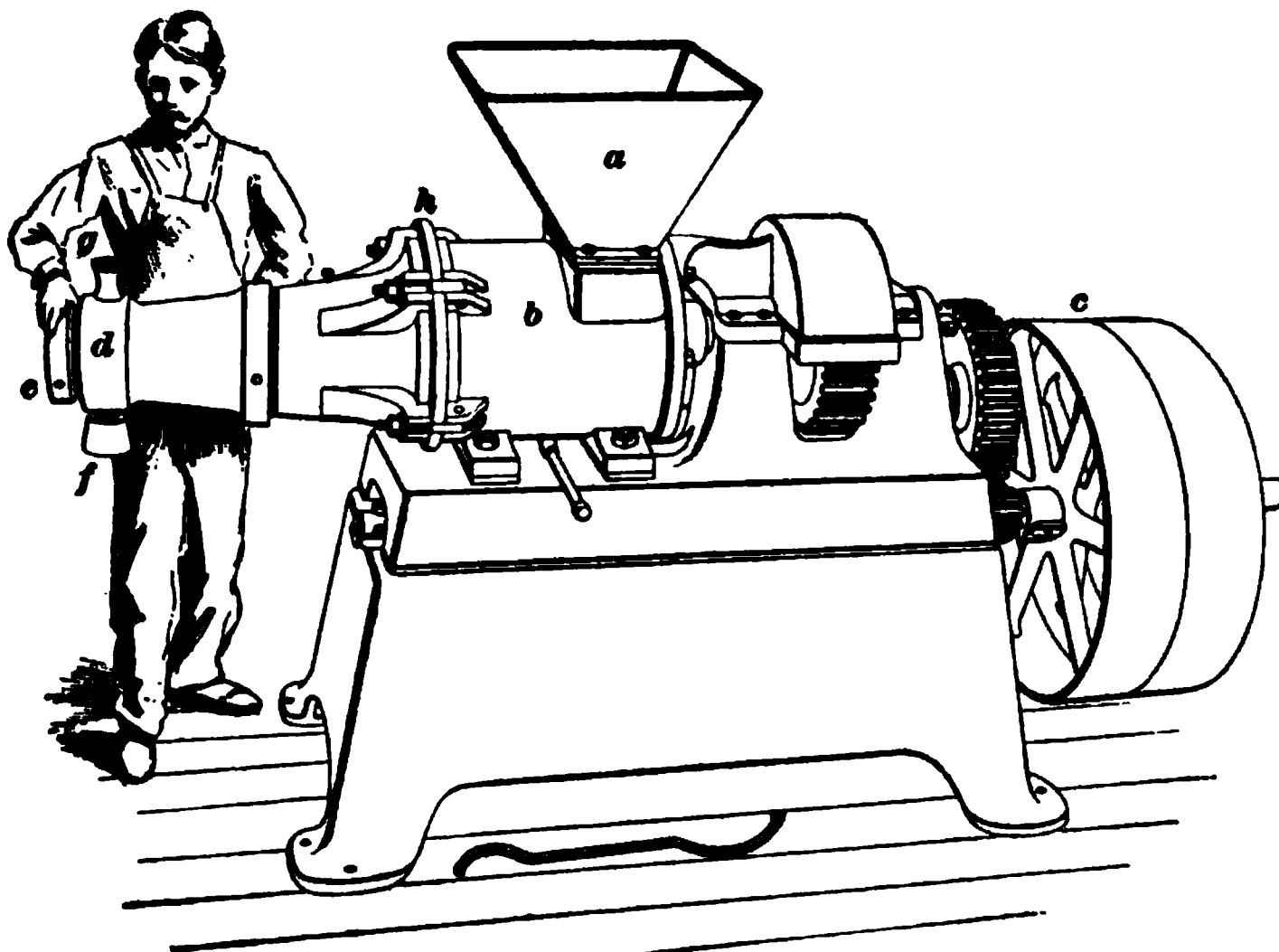


FIG. 6

The nozzle of the plodder is provided with a screw head, to permit the attachment of the cake former. With this arrangement, the elongated bar is made to assume any cross-section desired, as circular, square, or rectangular. The purpose of the hot-water jacket, shown at *d*, Fig. 6, is to soften the soap to such a consistency that, when forced through the cake former, the cohesion of the soap mass will not be destroyed and the soap will not, as it is termed, "crack" or "splinter." Plodders are rated according to the pounds of soap capable of being plodded per day under a maximum average compressive force.

**17. Cutting and Pressing the Plodded Toilet Soap.**

The soap as it is delivered from the nozzle of the plodder is carried to the cutting table, shown in Fig. 7. Here, the long bar is cut into separate cakes of uniform length by the wire *a* in the movable frame *b* operated by foot-power. The experience of the attendant will determine at this stage whether it is necessary to subject the soap to a slight superficial drying in order to obtain the best possible impression on stamping. If the soap is sufficiently dry, it is taken from the cutting

**FIG. 7**

table in trays to the soap press. Milled soap has always been pressed on the old-style foot-press, but with the improved automatic press, it is claimed that soap of this character can be satisfactorily pressed. From the press, the cakes are delivered to girls, who wrap and pack them in boxes.

**18. Continuous Crusher and Dryer.**—The patented process known as the continuous crusher and dryer possesses the double advantage of shortening the time of manufacture and of very materially decreasing the cost of

production. In this process, instead of slowly cooling great masses of soap in bulk, the paste is treated while still hot and in a liquid state, just as it comes from the kettle. While available for household and industrial soaps, this process is used almost exclusively for toilet soaps.

In the manufacture of toilet soap by the usual process, as previously explained, the material is taken from the kettle,

FIG. 8

crushed, framed, slabbed, caked, and chipped before passing to the drying room. By this special process, however, the hot soap passes directly from the kettle to the machine in which the drying is to take place, the only intermediate step being the pumping of the soap from the soap vat to the storage tank. This is done in order to elevate the soap above the crusher and dryer and to regulate its flow into the hopper *a*, Figs. 8 and 9.



The mixing tank *b*, Fig. 9, is discarded by most users of the machine, the color and perfume being added to the dry and cold soap in the mixer *f*.

A boiled settled soap is usually crushed while at a temperature of from 65° C. to 70° C., but soap can be pumped to this machine at a temperature of 80° C. The soap paste passes from the hopper to the first roller *c* of the five horizontal rollers *c* to *c'''*. The speed and pressure of these rollers gradually increase in the order in which they are lettered, being greatest at roller *c'''*. The soap paste striking the rollers curdles at once and gets crushed into thin layers, which a knife divides into ribbons. The soap leaves the roller *c'''* as a thin ribbon, or film, and falls on an endless band of wire gauze circulating in the drying chamber. These bands are shown through the open doors in the side of the apparatus, Fig. 8. The time required for the soap to pass from the hopper through the dryer to the box *d*, Fig. 9, is only about 12 minutes, during which period it travels the full length of the dryer a number of times, falling from one wire band to another.

The dryer is heated by the steam coil *e*, Fig. 8, and the hot and moist air passes away through the pipe *d*. The temperature maintained in the dryer is about 35° C., as this has been found to give the best results.

These machines are constructed in various sizes, and their output ranges from 250 to 800 pounds per hour.

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### PERFUMING OF SOAP

19. Competition in the toilet-soap business has reduced the profit to a very small margin. One important characteristic of this business is the manner in which the goods are put on the market. An attractive wrapper and an agreeable perfume are demanded by the inexperienced buyer of this class of soap to the exclusion of the essential qualities. By means of coloring matter and suitably blended essential oils, a milled soap made from very inferior stock may have its original inferiority completely obscured.

The blending of essential oils is a recognized art, whose development requires the constant attention and study of the skilled perfumer. The demand is always for something new, to supply which the toilet-soap manufacturer is often hard pressed. Organic chemistry has supplied the perfumer with a large and increasing number of artificial perfumes, which often surpass the natural source in intensity of fragrance and cheapness. Some of these, as nitrobenzene, or oil of mirbane, a cheap and efficient substitute for the oil of bitter almonds for perfuming laundry soap, are obtained from coal tar; others, as vanillin, borneol, menthol, eugenol, ionone, heliotropin, etc., are prepared synthetically; certain others are isolated from essential oils, as safrol, from oil of camphor, which has practically displaced the natural oil of sassafras as a soap perfume; citral, from oil of lemon; carvol, from oil of caraway; etc.

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#### PERFUMES USED IN LAUNDRY SOAPS

**20.** The following list of essential oils comprises those most commonly used for perfuming laundry soap. As has been noted, the proportion used seldom exceeds  $2\frac{1}{2}$  pounds per frame of 1,200 pounds of soap.

Oil of caraway seed.

Oil of cassia, with guaranteed percentage of cinnamic aldehyde.

Oil of cedarwood.

Oil of citronella.

Oil of mirbane, artificial, with odor of oil of bitter almonds.

Oil of rosemary.

Safrol, artificial oil of sassafras.

Oil of eucalyptus.

Oil of thyme.

The best way to ascertain the most satisfactory combination of essential oils for a laundry-soap perfume is to prepare a number of mixtures to be used experimentally as a basis, or vehicle, for a highly fragrant and strong-bodied essential oil, as artificial oil of sassafras, or safrol. This particular oil commends itself because of its cheapness. Its fragrance



may be modified by mixing it in varying proportions with other essential oils, not debarred by their high cost, until a mixture is obtained that is at once cheap, lasting in fragrance, and disguises most completely and agreeably the odor associated with the soap in use.

After two or three mixtures of equal satisfaction are obtained experimentally, the mixtures may be subjected to practical tests by studying results, when they are mixed in regulated proportions in successive frames of soap.

The formulas in Table I represent two mixtures, No. 2 being modified from No. 1 as the result of an advance in the price of cassia oil. Equally satisfactory results were obtained from both mixtures.

TABLE I  
FORMULAS FOR PERFUMING OF LAUNDRY SOAP

Essential Oils	Formula 1 Parts by Weights	Formula 2 Parts by Weights
Safrol . . . . .	23	27
Cedarwood . . . . .	12	10
Cassia . . . . .	9	7
Lavender . . . . .	10	10

Laundry soap is seldom colored, indigo paste being the only color that is used to any great extent. The blue soap thus produced often misleads the consumer into the idea that bluing is being added at the same time that washing is being done. Unbleached palm oil is the cheapest and most efficient agent available to disguise the odor and color of rosin. Very small quantities of ultramarine are used in some cases to heighten the whiteness of floating soaps. Disinfectant and tar soaps are colored, the former variably, the latter with pine tar.

**PERFUMING OF TOILET SOAP**

**21.** The direct application of the perfuming material to the mass of thin, shredded soap, after its preliminary treatment in the mill to obtain homogeneity, involves no especial difficulty. A weighed or measured quantity of perfume is simply added to the mass in the box in which the shredded soap accumulates as received from the mill, and the perfume is then incorporated sufficiently with the soap to enable the attendant to transfer it to the hopper of the mill without waste.

The blending of perfuming material to obtain desired odors, generally those imitating the natural odors of fresh flowers, constitutes a distinct art and requires for proficiency an intimate knowledge of the chemistry of essential oils and experience in working with them. The various ingredients of the perfumed stock may be bought separately and then compounded or blended by the perfumer, or they may be bought already blended from dealers in essential oils and perfumers' materials.

With the exception of musk and civet, which are excretory secretions of the animals producing them, the raw materials of soap perfumery consist chiefly of essential oils obtained from wood, as oil of cedarwood; from bark, as the oil of wild cherry; from foliage, as oil of eucalyptus; from fruit or seed, as oil of caraway; and from flowers, the chief source, as oil of rosemary.

There is a large and increasing number of synthetic preparations and isolated bodies possessing in a marked degree the fragrance of the natural source that now successfully compete with the latter. These bodies, as a rule, are the odoriferous principle of the natural oil, and for purposes of perfumery are not encumbered with the non-essential ingredients present in the natural oil. A correspondingly smaller quantity can be used to effect the same results and thus generally reduce the cost of production.

**22.** The fractional distillation of essential oils obtained from plants has shown that they are composed of a nearly odorless vehicle, consisting of one or more hydrocarbons of

the terpene class, a principal odorous constituent, which may be an alcohol, phenol, aldehyde, ketone, ether, or ester, and smaller quantities of various other compounds. These modifying constituents may vary in amount in oil obtained from different parts of the same plant.

In Table II the essential oils are classified according to their chemical composition and principal constituents.

TABLE II  
CLASSIFICATION OF ESSENTIAL OILS

Families	Principal Constituents	Oils
I. Alcoholic Terpenes and their Ethers	1. Borneol	Pine needle Valerian
	2. Linalool: dextrogyrate levogyrate	Linaloé Coriander Bergamot Lavender Aspic Sage muscatelle Neroli Petit grain Limetta Ylang-Ylang Cananga
	3. Geraniol and citronellol	Palma rosa Geranium Rose Citronella
	4. Menthol	Peppermint
	5. Sesquiterpenic alcohol	Patchouli Sandalwood Angostura bark Caparrapi
II. Aldehydes	1. Benzoic aldehyde	Bitter almond Wild cherry Cherry laurel
	2. Cumic aldehyde	Cumin Eucalyptus hæmastoma
	3. Cinnamic aldehyde	China cinnamon, cassia Ceylon cinnamon, cassia
	4. Citral and citronella	Lemon grass Melissa Citron Petit grain (lemon) Orange Mandarin Lemon Euca-lyptus { Backousia citrio- dora Staigeriana Dealbata Maculata

**TABLE II—(Continued)**

Families	Principal Constituents	Oils
III. Ketones	1. Methylnonylketone	Rue
	2. Irone	Iris
	3. Carvone	Caraway Dill Kuromoji Spearmint Mint crépue
	4. Pulegone	Pennyroyal Pennyroyal (American) Thyme
	5. Thujone	Tansy Thuja Wormwood Sage Artemisia (barrelieri)
	6. Fenone	Fennel
	7. Camphor	Camphor laurel Rosemary Marjoram
IV. Lactones and Anhydrides	1. Alantolactone	Elecampane
	2. Sedanolid and sedanonic anhydride	Celery
V. Phenols and Phenolic Derivatives	1. Thymol and carvacrol	Ajowan Thyme Wild thyme Monarda Satureja Origanum Curcuma
	2. Eugenol and betelphenol	Clove Massey bark Canello bark Bay Gulilvan Allspice Betel Paracoto bark Snakeroot (European) Snakeroot (Canadian) Matico
	3. Anisol and estragol	Anise Anise bark Estragon Persea Basilicum
	4. Safrol	Sassafras Oil of camphor
	5. Apiol	Parsley Camphor wood (Venezuela)
VI. Phenolic Aldehyde	1. Salicylic aldehyde	Reine des Prés
	2. Diosphenol	Buchu Diosma Creneta

**TABLE II—(Continued)**

Families	Principal Constituents	Oils
VII. Cineol		Eucalyptus Cajeput Cardamom Cheken leaf Galangal Laurel Laurel (California) Myrtle Zedoary
VIII. Terpenes and Sesquiterpenes		Turpentine Cypress Angelica Phellandrene Wormseed Ginger Frankincense Elemi Black pepper Cubeb Copaiba Gurjun balsam Juniper berry Cedar Hop Hemp
IX. Ethers of Alcohols of the Aliphatic Series		Camomile Heracleum Parsnip Wintergreen Cognac
X. Sulphur Compounds	1. Sulphides  2. Isosulphocyanates	Garlic Asafetida Onion  White mustard Black mustard Mignonette Cochlearia Achillea
XI. Constituents Un- known		Musk pear Mugwort Arnica Carrot Carlina Calamus Cascarilla Erigeron Galbanum Gualac wood Hyssop Masterwort Jaborandi Jasmine Champaca Lovage Myrrh Tea Vetiver

## MANUFACTURE OF PERFUMES

**23.** The essential oil constituting the natural odor of vegetation, whether of the wood, bark, foliage, flower, or fruit, may be extracted by any one of five distinct methods, namely, *distillation*, *maceration*, *enfleurage*, *extraction with volatile solvents*, and *mechanical means*.

**24. Distillation.**—In the distillation method, the raw material is mixed with water in a boiler and subjected to heat, preferably steam. The essential oil is thus driven off with the steam that is condensed, allowing the essential oil and water in separate layers to be collected in a receiver. As a process of extraction, distillation involves the greatest danger of decomposition and loss of the product desired. It is usually employed for the extraction of oils from the woody portions of the plant, although the delicate perfumes of the rose and the orange flower will withstand distillation.

**25. Maceration.**—The maceration method consists in immersing the flowers in melted and very pure lard or tallow. For preparing perfumed oils, olive oil is generally used. The absorption of the odorous principle is hastened by renewing the charge at frequent intervals as absorption progresses. The mass may be used either directly as a pomade or extracted from the fat with alcohol, forming the “extracts” of the perfume trade. Maceration is applied to the violet, jonquil, rose, and orange flowers. The process is usually carried out by women, who keep the flowers submerged in the melted fat, at a temperature of about 65° C., for about  $\frac{1}{2}$  hour, by means of spatulas. When sufficiently exhausted, the flowers are removed, drained, and pressed free from adhering fat. The process is repeated with the same fat until it has been saturated to the desired strength.

**26. Enfleurage.**—The enfleurage method differs from the maceration method in that the absorption takes place in the cold. This process is used for the most delicate and elusive odors, as the jasmine and the tuberose. In this process, the flowers or petals are laid on thin layers of

grease spread out on the glass bottoms of shallow rectangular frames. The separate frames charged in this manner are then arranged one above another in piles. The flowers remain in contact with the grease for about 24 hours and are then removed and fresh flowers added. This process is continued until the grease is sufficiently saturated. In some instances, as with the jasmine, upwards of 2 to

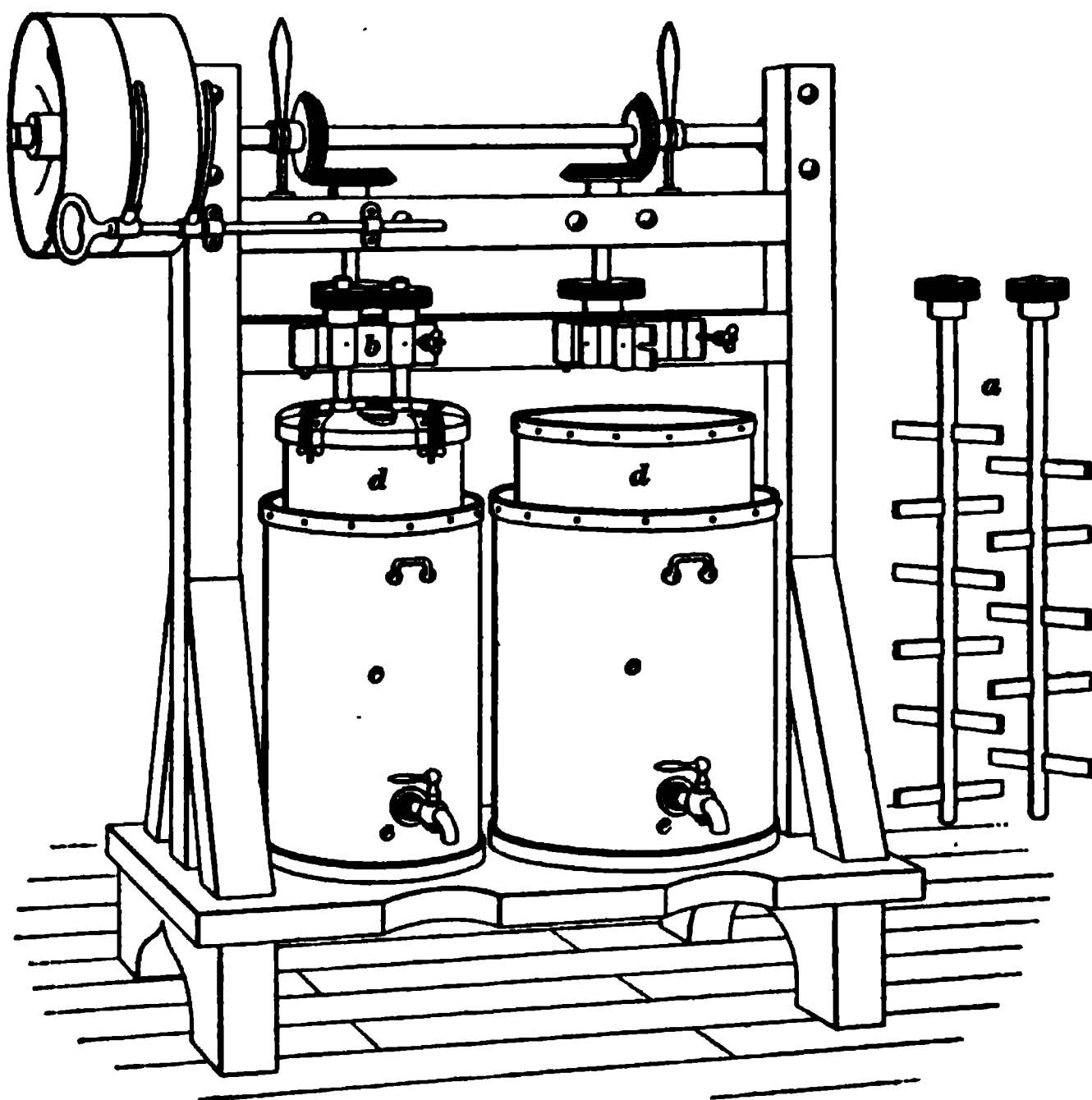


FIG. 10

3 months is required. To make perfumed oils by this process, a cloth saturated with olive oil is spread on the wire-gauge bottom of a wooden frame and receives the fresh flowers. Enfleurage is the most delicate of the five methods and gives the best results.

**27. Extraction With Volatile Solvents.**—The method in which extraction is made with volatile solvents finds very limited application as a process applied directly to the

raw material. It constitutes the final treatment of the perfume obtained by maceration and enfleurage. The scented fat, if solid, is called *pomade*; if liquid, *huile antique*. The odorous material is separated from the fat vehicle by means of a pomade washer, shown in Fig. 10. This machine is simply a crutcher with detachable mixers held firmly in place by the lock *b*, the whole being enclosed by a water-cooling jacket *c*. The pomade, with the solvent, usually alcohol, is added to the tank *d*, the crutches *a* being inserted and firmly locked at *b*. The cover of the crutcher is now firmly clamped down and agitation begun. When solution is complete, the liquid is withdrawn through a faucet at *e*. The solution is then distilled over a water bath, and the alcoholic solution of the essential oil is collected in the usual manner in a receiver. The temperature of distillation is very important, for with delicate odors, which are of complex composition, there is danger of loss through decomposition. As it is impossible to remove the last traces of oil from the fat, this exhausted pomade is used over again.

**28. Mechanical Means.**—For the extraction of the volatile oil from the heavy rinds of citrous fruits, such as the orange, lime, and lemon, mechanical means are employed. The nature of the device used varies with the scale of operation. With large quantities, the material is subjected to heavy pressure in a specially constructed press, similar to that used for the extraction of cottonseed oil from cooked seed. For small quantities of material, a shallow metal cup with a hollow handle projecting from the bottom and continuous with the cup is used. See Fig. 11. The interior surface of the cup is provided with barbs, or spikes, which

FIG. 11



lacerate the material rubbed on them. The oil thus liberated collects in the hollow handle and is poured off through the groove *a*.

#### SYNTHETIC PREPARATION OF PERFUMES

29. Chemical synthesis today furnishes many of the perfumes that were originally and are still to a large degree obtained from plants. While many of the artificial perfumes have not the intensity of odor of the isolated natural bodies, their greater cheapness guarantees them an eager and enlarging market. In order to present an idea of the methods used in the manufacture of these interesting synthetic products, the preparation of three popular synthetic perfumes will be described.

Great care is required in carrying on the several operations of a single synthesis. Organic reactions, especially with bodies of complex composition, are difficult to control, and unless carefully guided are likely to produce bodies widely different from those desired.

30. Cumarin, a lactone,  $C.H. \begin{array}{l} \diagup O \\ \diagdown CH \end{array} - \begin{array}{l} CO \\ | \\ CH \end{array}$ , is the

source of the odor of the Tonka bean. It is prepared from 3 parts of salicylic aldehyde, 5 parts of acetaldehyde, and 4 parts of anhydrous sodium acetate. This mixture is heated in a flask for several hours, until the reaction is complete. It is then allowed to cool until the mass becomes solid. On the addition of water, an oil separates; this oil, on distillation, yields cumarin, which is then crystallized from alcohol.

31. Heliotropin, an aldehyde,  $CH. \begin{array}{c} \diagup O \\ \diagdown O \end{array} C.H. - COH$ , is

obtained synthetically from isosafrol, a modified form of safrol; 150 parts of concentrated sulphuric acid, 100 parts of bichromate of potash, and 350 parts of water are mixed and carefully added to 20 parts of isosafrol. The mixture develops more or less heat, which, if not carefully regulated, greatly influences the character of the resulting product and the

yield. The mixture is then distilled over with steam, and the distillate is purified by extraction with ether. By virtue of its aldehyde character, the distillate is further purified by isolating it as a bisulphite compound. The washed crystals are then decomposed with sodium-carbonate solution. Heliotropin possesses the characteristic odor of heliotrope.

**32.** Ionone, a ketone, is the artificial perfume of fresh violets. Equal parts of citral and acetone are mixed with barium-hydrate solution. On completion of the reaction, the mixture is extracted with ether and the residue from the ethereal extract is subjected to distillation at a pressure of about 12 millimeters of mercury. The fraction boiling between 138° and 155° C. is further purified by redistillation at the same pressure. The oily distillate is called *pseudo-ionone*. This product is transformed into ionone by heating carefully with dilute sulphuric acid.

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### COLORING OF TOILET SOAP

**33.** The coloring of toilet soap is a very simple process. If the color is used in the dry state, it is either simply dusted on the soap in the hopper of the mill, spread on the thin soap while passing between the rollers of the mill, or added to the soap in the box after it has received its preliminary milling. The application of the coloring material in solution is preferable to using material in the dry state, as it admits of a more homogeneous distribution of the color in the shortest time.

There should be a consistency between the nature of the coloring material used, the odor of the perfume, the character of the soap, and the name applied to it.

The *organic coloring materials* commonly used are obtained from coal tar and receive trade names that give no indication of their composition to the purchaser. Red, pink, orange, yellow, green, brown, blue, and lilac colors are obtained already compounded from dealers in perfumers' materials and with guaranteed solubility in definite parts of hot or cold

water. The primary qualifications of a soap dye are inertness to the action of alkali and permanency under the conditions in which the soap is used.

In Table III are given the chief materials used for producing various colors used in the coloring of toilet soap.

**TABLE III**  
**COLORS USED IN SOAP AND CHIEF MATERIALS FOR**  
**PRODUCING THEM**

Color	Material
Red . . . . .	Coal-tar colors: vermilion, Venetian red, alkanet, bole, colcothar, cinabar, chrome red, carmine.
Orange and yellow . .	Coal-tar colors: chrome yellow, cadmium yellow, curcumin, gamboge, turmeric.
Green . . . . .	Coal-tar colors: ultramarine green, chlorophyl extract.
Brown . . . . .	Coal-tar colors: brown oxides of iron, mixed blue and yellow colors.
Blue and lilac . . . .	Coal-tar color: ultramarine blue.

The intensity of the color is determined by the amount of dye used and the character of the soap. Coconut oil, for instance, as an ingredient of a toilet-soap base will permit of greater brilliancy than would be possible without its use.

## MANUFACTURE OF SOAP POWDER

**34.** The manufacture of soap powder in recent years has grown into a business of considerable magnitude. The earliest of those engaged in its manufacture found the business extremely profitable, but with growing competition the margin has been considerably reduced. Well-made, settled, resinous soap can be filled with upwards of 10 per cent. of soda-ash solution with good results. If this filling is increased in quantity until present in the mixture greatly in excess of the soap, there results a compound that, when reduced to a finely divided state, constitutes the soap or washing powder of trade. The first consideration in the manufacture of soap powder is the composition of the soap base. Any glyceride soap stock is available for this purpose. Rosin, which forms a soft, sticky soap, with great affinity for water, resulting in the formation of lumps in the powder, should not be used, or at best only in small proportion and in combination with a firm tallow base. The prime requisites of a soap powder are freedom from lumps and uniformity of size of the particles composing it. Some soap powders are more finely divided than others, the degree of pulverization being determined by either the fancy of the manufacturer or the demand of the trade.

The manufacture of soap powder is a simple operation, requiring comparatively little outlay for apparatus. As with all manufacturing operations, success is determined not by the ease, simplicity, or cheapness of production, but by the volume of sales of the product. However, few proprietary soap powders have a general sale, the great majority of them being confined to a strictly local market.

**35.** Any settled or semiboiled non-resinous soap may be used as the soap base. If circumstances do not warrant the separation of the glycerine by graining the soap, a simple

semiboiled soap composed of suitable ingredients will satisfy every requirement. In outlining the process of manufacture, a kettle charge of 10,000 pounds of grease will be considered. This will require for saponification 10,000 pounds of 20° Baumé caustic-soda lye, yielding in the kettle, by the semi-boiled process, upwards of 20,000 pounds of soap. In killing the stock, follow the directions outlined under the stock change in the manufacture of settled rosin soap. When the stock has been completely saponified and the mass thinned out, or boiled to the proper consistency, it can be crutched at once if the manufacturing operations so demand. It is best, however, to let the stock settle and cool over night.

If settled soap that has been grained, strengthened, and then thinned out to the usual consistency is used, it will give the customary yield of 50 per cent. and contain about 30 per cent. of water. With soap made as just described, the yield is 100 per cent. and contains over 45 per cent. of water. This will give a very liquid soap, to which the soda ash in the dry state can be directly added. With an ordinary settled soap, it will be necessary to add a portion of the soda ash in saturated solution, depending, however, on the quantity desired to be added. This liquid addition thins out the soap and thus enables it to incorporate more dry soda ash than it otherwise would.

There is now on hand 20,000 pounds of semiboiled soap. To make a soap powder containing 1 part of soda ash to 1 part of soap (which proportion will yield a good powder), it is necessary to add 20,000 pounds of soda ash, giving a yield of 40,000 pounds of soap powder from 10,000 pounds of grease.

**36. Crutching, Slabbing, and Drying.**—In crutching, pump the crutcher one-half full of soap and start it, adding gradually the requisite quantity of soda ash that has been previously weighed out. When the mixture has been made homogeneous, it is dropped into the frame and slabbed as soon as it has cooled sufficiently to permit the removal of the frame sides. The slabs are cut into narrow bars of a

length corresponding to the width of the frame. These bars are then racked and dried.

Soap and soda ash are generally mixed in large quantities at a time and reduced to powder as required. When sold in quantities, it is usually shipped in barrels; when intended for the retail trade, it is packed in cartons marked with the brand and the name of the manufacturer.

**37. Soap-Powder Mill.**—The soap-powder mill is of especial importance in the manufacture of soap powder, and should be so constructed as to do the work quickly, without heating the powder, and with a minimum of dust and repairs. The machine shown in Fig. 12 receives the bars of soap

FIG. 12

powder, previously broken into lumps, in a hopper attached to the collar *a*, and crushes, grinds, and sifts them in one continuous automatic operation. The lumps are reduced by repeated blows of rapidly revolving steel blades, or beaters, enclosed in the semicylindrical casing shown at *b*. The powder is discharged through a semicylindrical screen, which serves as a sifter and which forms the under side of the casing *b*. Power is applied by belt at *c*. The mill is mounted on a well-braced framework that is completely enclosed to retain dust and high enough to admit the introduction of a barrel to receive the powdered material.

## RECOVERY OF GLYCERINE FROM WASTE SOAP LYE

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### MANUFACTURE OF GLYCERINE

**38. Historical.**—Scheele, in 1779, when preparing lead plaster by heating olive oil with litharge, obtained a soluble, sweet-tasting substance, and later, in 1784, he found that the same substance could be obtained from other oils, as well as from butter and lard. To this material he gave the name “the sweet principle of fats,” and it afterwards bore the name of Scheele’s sweet principle, or oil sugar.

Lead plaster is said to have been discovered by the Roman physician Menecrates about the middle of the first century, and also to have been known to Pliny, who briefly described its uses, mode of preparation, and application, but nothing was known of *glycerine* until Scheele’s day.

Later, the body was more carefully investigated by Chevreul, who determined its composition with tolerable exactitude and gave to it the name that it now bears. Pilouze in 1836 first established its formula. His experimental results corroborated Chevreul’s views that the fats are ether-like compounds of the fatty acids. Henceforth *glycerine* became the subject of study by Berzelius, Liebig, Berthelot, and de Luca; but it remained for Wurtz to determine its exact chemical composition and relation to other bodies of the aliphatic series.

Scheele published the results of his investigations in a communication that appeared in the Transactions of the Royal Academy of Sweden, in 1783. He describes his method of preparation in the following terms: “It is not generally known that all solid oils obtained by pressure contain a natural sweet principle which differs in its special relations and properties from the other well-known saccharine

materials occurring in the vegetable kingdom. This sweet principle makes its appearance when oils of this kind are boiled with litharge and water until the whole of the litharge is dissolved by the oil. Water is then poured upon the 'emplastrum simplex' thus formed, the whole boiled for a few minutes, and on cooling the liquid is filtered off from the plaster and boiled until the residue becomes sirupy."

**39.** Glycerine was prepared by the foregoing process alone for many years, the lead introduced as an impurity from the litharge being removed before concentrating the filtrate by the use of hydrogen sulphide. This concentrated filtrate, after some primitive clarification, constituted the glycerine of commerce. Its rapidly increasing use soon demanded its production on a larger scale. It was known that in the process of soap making the glycerine liberated from the fat in the act of saponification remained in the waste lye, but efforts to recover it from this medium with the extremely crude methods used were unsuccessful.

In the meantime the manufacture of stearin candles was undergoing important developments. Numerous patents were granted for processes for the decomposition of the fats and the separation of glycerine. Gay-Lussac and Chevreul, in 1825, were the first to obtain patents. Their patent was for the alkaline saponification process, which, however, did not admit of successful operation until after the improvement by de Milly, in 1831. This is the autoclave process at present in use.

During the succeeding 20 years the sulphuric-acid distillation process was proposed and developed. Although other investigators had worked with the problem, and in fact a form of the process was in actual use by the predecessor of the Price Patent Candle Company, it remained for an American chemist, R. A. Tilghman, to determine the conditions productive of the most successful results. For his originality he received a patent in 1854, having previously filed a caveat. An English patent was soon after taken out. Tilghman's process is the one at present employed in



conjunction with the use of sulphuric acid and is described in *Manufacture of Soap*, Part 1.

40. In 1847, Sobrero, in Paris, discovered *nitroglycerine*. Alfred Nobel demonstrated its value as an explosive in 1863 and in 1866 invented *dynamite*. This was followed in 1875 by *blasting gelatine*. The construction of vast engineering undertakings was greatly facilitated by the use of these substances, of which glycerine is the basis. The increased use of glycerine reacted directly on the source of the raw material, and the soap trade soon came to a perplexing realization of the increasing value of the product that was being daily consigned to the sewer.

41. **Treatment of Waste Lye.**—In the discussion of the manufacture of settled resinous soap, the progress of a boil of soap was traced, showing the formation of the various lyes. These are dilute solutions of varying percentages of sodium hydrate, sodium carbonate, sodium sulphate, sodium chloride, and glycerine, and are contaminated by more or less soap in suspension, together with coloring matter introduced by the rosin and with some mucilaginous matter or animal tissue remaining in the stock when rendered. This liquor, which often has a foul odor and is a by-product with the soap maker, now becomes the raw material of the glycerine refiner.

The process and apparatus used represent the culmination, in efficiency and simplicity, of all systems of glycerine recovery from waste lye. It has been declared impossible to prepare a chemically pure glycerine from waste lye—that glycerine of dynamite grade represents the limit in purity of glycerine obtained from this source. Soap lye, by the improved treatment at present in use, is made to yield a glycerine of the highest purity and answering the severest requirement of any pharmacopœia. In the process that has received the substantial approval of general practical use, the agents employed for the precipitation of albuminous and soapy matter and the neutralization of the alkali present in the lye are oil of vitriol and a basic sulphate of iron.

The basic sulphate of iron is prepared by treating pulverized iron ore with sulphuric acid, whereby an acid salt mixed with some uncombined ore and acid is obtained. This mixture is subsequently subjected to a high temperature, namely, 380° to 500° F., under which condition it undergoes a transformation into a basic sulphate of iron. The efficiency of basic sulphate of iron as a clarifying agent depends on the formation of ferric hydrate and insoluble iron soaps that entangle completely the albuminous matters, all of which in settling through the liquor clarify and decolorize it.

42. In the glycerine refinery, the waste lye as it is received is usually elevated to the top of the building, where it is reserved in storage until it has cooled sufficiently to allow the impurities to settle out and the small amount of soap contained in it to rise to the surface. This soap is skimmed off and returned to the soap factory. If this precaution is not taken, the excess of fatty acids will cause trouble by retarding the flow of liquor through the filter presses.

The waste lye is lowered by gravity to the mixing tank, where it receives the proper proportions of sulphate, previously dissolved in hot water and vitriol. One-half of 1 per cent. of sulphate usually suffices to remove all impurities present. Sufficient vitriol is used to neutralize the lyes to such an extent as to leave their alkalinity .02 per cent. The sulphate, by virtue of some free acid that it contains, acts also as a neutralizing agent. After this preliminary treatment, the lye is filtered by means of a filter press and is ready for the first evaporation.

The lye may undergo other treatment, as, for instance, a repeated precipitation, to render more effective and complete the clarification and decolorization.

43. Since the process used in making the persulphate of iron is patented, and the salt therefore expensive, many soap manufacturers employ the following method for the treatment of the lyes:

The lye is first treated with .25 per cent. of slaked lime made into a thin paste with water. After agitation with air for 30 minutes, the lye is allowed to settle for 3 hours, during which time the lime soaps that have been formed settle to the bottom of the tank. The lye can then be easily siphoned through the filter press to the second tank.

In the second tank, sufficient hydrochloric acid is added to leave the lye .05 of 1 per cent. on the acid side. After removing the resinous soap by skimming,  $\frac{1}{8}$  of 1 per cent. of aluminum chloride, 20° Baumé, and .03 per cent. of kaolin, mixed with a small amount of water, are added. These remove the last traces of fatty acids and reduce to a minimum the volatile acids in the finished product, which is refined glycerine.

After subsidence, the lyes are run without filtering to a third tank, where just sufficient saturated caustic-soda solution is added to render the lyes alkaline to litmus paper, which is about .01 per cent. alkalinity.

The tanks to be used for the second and third treatments must be lead-lined, and the lyes in them must be agitated with air during the addition of the chemicals and for a short time afterwards.

**44. Evaporation of the Lye.**—The purified lye is now drawn by vacuum into the lye evaporator, shown in Fig. 13. This apparatus consists of cylindrical tanks of sheet steel supported on pillars and provided with pipes for the removal of vapor, for the entrance and exit of steam, and for the introduction of fresh lye, and also with manholes for cleaning and for the removal of salt and evaporated lye. The tanks are also provided with gauges for the indication of vacuum, steam pressure, and level of liquor, and a device for the collection of samples. Evaporation is effected by the use of either exhaust or live steam, which is admitted into a chamber filled with vertical tubes through which the lye passes. Intimate contact with the source of heat is thus obtained. A vacuum of about 28 inches is maintained with the regulation wet-air vacuum pump. The pipes through

which the vapors pass from the boiling liquor connect with catch-alls for the collection of entrained matter, and these in turn communicate with the vacuum pump.

In this evaporator, Fig. 13, *a* is the pipe for the entrance of live or exhaust steam into the steam chest shown in section at *g*; *b* is the outlet for the water of condensation from the steam chest, the level of which is shown by the gauge

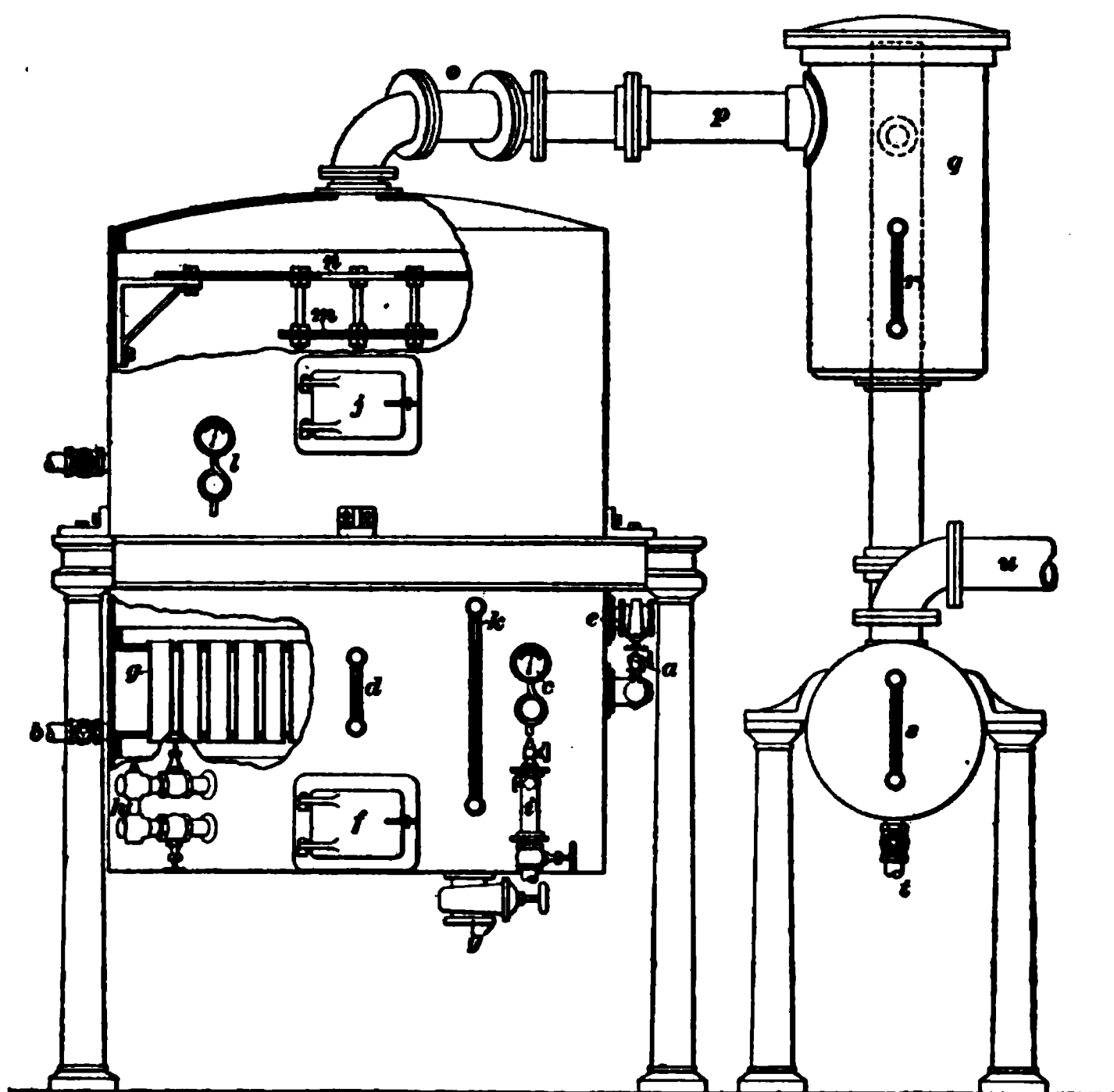


FIG. 13

glass *d*. The pipe *e* is for the introduction of the liquor to be evaporated. The door *f* is for the removal of the salt. The pipe *g'* is for the removal of the concentrated liquor. The pipes *h* are to enable the attendant to discharge the concentrated liquor close to the level of the salt. The device *i* is for the removal of samples. The door *j* is to permit an examination of the interior of the evaporator. A gauge

glass *k* shows the level of liquor in the evaporator. The vacuum gauge *l* shows the vacuum inside the evaporator. The baffle plates *m* and *n* prevent the entrainment of liquor through the pipes *o* and *p* into the catch-all *q*, which is provided with the gauge glass *r*, to indicate the level of any liquor it may contain. A horizontal cylinder *s* collects the entrained matter, which may be removed through the outlet *t*. The pipe *u* leads to the vacuum pump, by means of which a vacuum is maintained in the system.

45. Evaporation is continued in the lye evaporator until a concentration of over 26° Baumé is indicated. The vacuum is then broken through the pipe *u*, Fig. 13, and the concentrated lye is discharged through the pipe *g'*. The door *f* is then opened and the lye is allowed to run on a filter, on which the crude salt is afterwards scraped. Suction is applied to the wet salt and the lye is thoroughly removed. The chief mineral constituent is  $Na_2SO_4 + 12H_2O$ , or Glauber's salt. The recovered salt is washed so as to eliminate the last traces of glycerine, dried by suction, and returned to the kettle room to be used in graining soap, thus completing the circle. The 26° Baumé lye, as it is now called, is a saturated salt solution. The percentage of glycerol is generally about twice as great as that of the fresh lye, the volume of the latter having been reduced practically one-half.

46. The object is to remove as much salt as possible from the waste lye concentrated in the evaporator shown in Fig. 13. The more salt there is separated here, the less remains to be removed in the subsequent evaporation. The concentrated lye is now subjected to a second and final evaporation, during which *crude glycerine* is produced. This may be effected in the same evaporator, but in large plants a smaller evaporator of precisely the same construction is used. The separation of the salt from the crude glycerine is also effected in the same manner as just described.

### TREATMENT OF CRUDE GLYCERINE

**47. Crude glycerine** contains from 75 to 85 per cent. of glycerol, about 6 per cent. of salts, chiefly sodium chloride, about 5 per cent. of organic matter, constituting the *foots* obtained on subsequent distillation, while the remainder is water. It is a thick, viscous liquid, its color and clearness depending in a great measure on the efficiency of the preliminary treatment that the fresh lyes have received for the removal of organic matter, including iron salts of the organic acids.

**48. Distillation of Crude Glycerine.**—The crude glycerine is withdrawn into storage tanks, from which it is transferred, as required, to another vacuum apparatus in which the distillation is conducted. This apparatus comprises a large cylindrical sheet-iron tank, in which the crude glycerine is distilled, and a series of vertical pipes terminating at the bottoms in horizontal cylindrical reservoirs, in which the distillate condensed in the vertical pipes collects. These reservoirs are termed *catch-alls*, and are usually from three to five in number. At the end of this series of receivers are two larger horizontal cylindrical vessels surmounted by an iron cylinder filled with water-cooled tubes, through which the more volatile portion of the distillate passes and is condensed, falling into the reservoirs below. These vessels, called *sweet-water drums*, communicate with a dry-air vacuum pump, which maintains a vacuum of about 28.5 inches throughout the system.

As a rule, there are two of these stills, with their accompanying condensers and receivers, the same pump maintaining a vacuum in both. The distilling vessel is of various sizes, depending on the capacity of the plant. It is a well-made, upright sheet-iron cylinder about 5 feet in diameter and about 10 feet in height. Steam at a pressure of 125 pounds, corresponding to a temperature of 345° F., circulates in a closed coil and maintains a constant temperature.

**49. Advantage of System.**—The essential advantage of this system of glycerine distillation consists in the injection of expanded and reheated steam into the body of crude glycerine maintained at a high temperature. Glycerine has a boiling point of  $290^{\circ}$  C., or  $554^{\circ}$  F. Under atmospheric pressure, however, it cannot be heated to this temperature without undergoing decomposition. By reducing the pressure, as is done in a closed vessel when a vacuum is maintained, it boils without decomposition, and its vapor may be condensed unchanged. Commercial crude glycerine is very impure, the organic matter present causing difficulty in the refining process. To separate this organic matter effectually, recourse must be had to some means other than boiling at a lower temperature under reduced pressure. To accomplish this, a jet of expanded and reheated steam is introduced into the mass of crude glycerine heated to the temperature of distillation.

If steam at boiler pressure, namely, 125 pounds, were used directly for distillation without being previously expanded and reheated, its expansion in the distilling apparatus would not only greatly retard, but would practically stop, the operation. To the great loss in heat due to absorption by the expanded steam would be added the difficulty arising from its condensation. These adverse and prohibitory conditions are eliminated by the use of expanded and reheated steam, which is prepared in the following manner: Steam taken directly from the boilers is allowed to expand in a coiled pipe of larger diameter located inside of a well-insulated vessel, called a *reheater*, which is attached to each still and in many cases is larger than the still itself.

The steam in expanding suffers a reduction in temperature. The heat lost is restored by surrounding the coil within the reheater with the same unexpanded steam from the boiler. Steam thus treated is introduced directly into the crude glycerine, which distils without decomposition at a temperature of about  $300^{\circ}$  F. Before introducing the steam, crude glycerine is added in sufficient quantity to cover the jet pipe to a satisfactory height, as indicated by the gauge glass, and

as the distillation continues, crude glycerine is added from time to time in quantities not too great to interfere with the

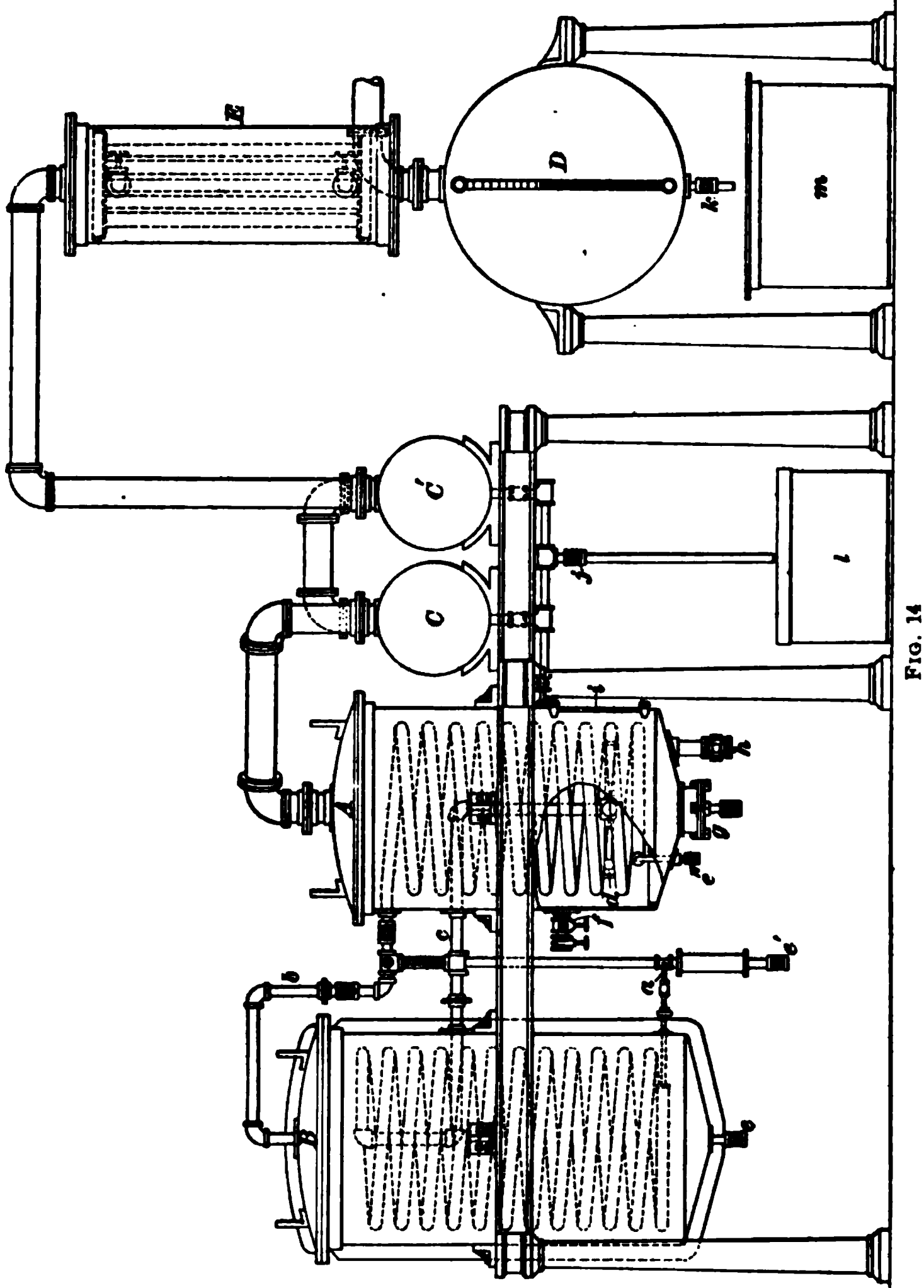


FIG. 14

even working of the still, never, however, allowing it to fall below the established level. If, from lack of attention on the part of the attendant, an excessive quantity is introduced,



there is great danger of the entrainment of the impurities contained in the crude glycerine, which increase in quantity in the still as the distillation proceeds.

**50. Crude-Glycerine Still.**—Referring to the still shown in Fig. 14, *A* is the still proper, *B* the reheater, *C* and *C'* the catch-all drums, and *D* the sweet-water drum. In the still *A*, the closed coil, shown in dotted lines, carries steam at boiler pressure, which heats the contents of the still to the temperature required for distillation. In the reheater *B*, steam at a pressure of 125 pounds enters through the pipe *a* and expands into the coil of larger diameter, which is shown in dotted lines. This expansion coil is surrounded by steam at boiler pressure entering the reheater through the pipe *b*, which also carries steam at the same pressure into the reheating coil of the still *A*. Expanded and reheated steam from the reheater enters the still through the pipe *c* and discharges into the crude glycerine contained therein through the crisscross jet shown at *d*. The catch-all stuff, so called, collects in the catch-all drums *C* and *C'*, and the lighter portion of the distillate condensed in the water-cooled jacket at *E* collects in the sweet-water drum *D*. At *e*, *e'*, and *e''* are outlets for the water of condensation from, respectively, the reheater *B*, the high-pressure steam line from the boiler, and the heating coil of the still *A*. At *f*, crude glycerine is fed into the still by suction. At *g* is the drop door through which the foots in the still *A* is discharged. Water used for washing the still is discharged at *h*. The level of the contents of the still is shown by the gauge glass *i*. At *j* and *k* are the discharge valves for the contents, respectively, of the catch-all drums *C* and *C'* and the sweet-water drum *D*. Tanks *l* and *m* are reservoirs for these respective portions of the distillate. All steam pipes leading to and from the apparatus, as well as the still and reheater, are insulated so as to retain the heat.

Before beginning a distillation, it is customary to have in stock a considerable quantity of crude glycerine, so that there will arise no necessity of shutting down the apparatus

before conditions in the still render it imperative. Fresh lye is undergoing concentration all the time, and naturally the product of one operation comes in greatly reduced bulk to be the raw material of the next.

**51. Products of Distillation.**—The products of the distillation of crude glycerine may be separated into three classes, namely, material collected in the catch-alls; technically called *half refined*, from its degree of purification; material of a much lighter gravity, called *sweet water*, consisting chiefly of water containing from no glycerine at all to as high as 12 per cent.; and a black, viscous residuum left in the still constituting the *foots*.

**52. Half-Refined Glycerine.**—The **half-refined glycerine** that is collected in the catch-all drums *C* and *C'*, Fig. 14, is of a bright straw color. This product undergoes a second distillation, during which its purity is greatly increased. After the second distillation, it undergoes a concentration to expel all water, whereupon it is run into drums and is ready for the market.

**53. Sweet Water.**—The material known as **sweet water** is concentrated to the consistency of crude glycerine and is then distilled and the distillate concentrated, as explained for half-refined glycerine.

**54. Foots.**—There remains to be considered the black residuum, or **foots**, in the crude-glycerine still. All the organic matter not removed in the preliminary treatment of the lye accumulates in the still and forms this black, viscous residue, which, if the distillation is carried too far, becomes so hard as to be removed from the still only with great difficulty. To facilitate its easy handling and the recovery of the large quantity of glycerine retained by it, the distillation is checked at that stage beyond which there is danger of contaminating the distillate with entrained matter from the still. The quantity of glycerine present depends on the concentration and is about 50 per cent.

In the distillation of crude glycerine, the organic compounds of sodium do not precipitate as do the inorganic compounds, namely, sodium sulphate and sodium chloride, and the former, as the mass in the still undergoes concentration, remain to constitute the foots. There are present, usually, about 5 per cent. of salt, from 20 to 30 per cent. of sodium acetate, and from 10 to 15 per cent. of sodium salts of non-volatile organic acids.

55. While still soft and comparatively fluid, the foots are transferred to a tank and neutralized with oil of vitriol. After the gradual addition of the diluted acid and filtering, the product is concentrated, forming crude glycerine from foots; this is then distilled. About 1,200 pounds of foots is obtained from every 10,000 pounds of crude glycerine, yielding on distillation about 50 per cent. of glycerine.

The glycerine obtained by the process described constitutes the dynamite glycerine of commerce. It is of a pale straw color and requires only subsequent distillation and filtration through bone black to become the water-white, chemically pure glycerine of the pharmacopœia. Its specific gravity is an important physical characteristic, and is subject to considerable variation. A density of 1.263 at 15° C. is commonly obtained.

A sample from each run of refined glycerine is analyzed for sodium chloride, ash, carbonaceous residue on ignition, and for acidity, both free and combined, in addition to a determination of the specific gravity. Samples, on standing, tend to accumulate color, due doubtless to an oxidation process of a nature not clearly understood.

56. The chemical examination of the product, not only during the various stages of the refining process, but also at its completion, is a matter of the utmost importance. By this close watching the refiner is warned of changes too delicate for observation, and is thus able to correct in its first stages any abnormal behavior that would deteriorate the final product.

The examination of the refined glycerine not only indicates the care exercised in the refining, but forms the basis for the valuation and sale. The influence exerted by foreign matter in the glycerine on its subsequent use in nitration and the manufacture of dynamite demands a searching chemical and physical examination that is entirely warranted by the danger attending these processes.

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## CHEMICAL EXAMINATION OF RAW MATERIALS AND PRODUCTS

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### INTRODUCTION

**57. Importance of Chemical Examination.**—Every large soap manufactory maintains a chemical laboratory and employs a trained chemist whose duty it is to examine all raw materials, thus enabling the purchasing department to avoid losses incident to misrepresentation and to insist on a high grade of material being offered. The chemist analyzes soap and similar products made by competitors, in order to obtain the necessary information whereby his employer is enabled to duplicate it promptly, if desired, at the same or a lower figure. He examines daily the various products that occur in routine factory work and promptly informs the superintendent of conditions requiring modification or elimination. Glycerine recovery cannot be carried on with complete satisfaction without some knowledge of the chemical principles involved in its formation in soap manufacture and its recovery from waste-soap lye. Refined glycerine is sold under a guarantee of its quality, to determine which skill in chemical analysis is necessary. As soap manufactories grow in size and as competition increases, the services of a chemist become more indispensable. It may be truthfully stated that the development of the soap industry to its present proportions would not have been possible without the aid of the chemist.

In *Quantitative Analysis* is given a thorough discussion of the analysis of fats, waxes, and mineral oils, and also a general résumé of the subject of soap analysis. The discussion at this time of analytical methods employed in the laboratory of the soap works is supplementary to the information given in the above-mentioned Section.

**58.** In industrial laboratory work, owing to the quickness with which the information obtained by chemical analysis is desired, many of the analytical methods given in technical treatises are seldom or never used, or only in part. In the routine laboratory work, absolute accuracy, while desired, is not required in every case, it being sufficient that successive determinations be performed as accurately as the time will permit and that they be uniform, for with uniformity of manufacturing operations, the analytical results must be on a perfectly comparative basis.

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#### EXAMINATION OF SOAP STOCK

**59. Collection of Sample.**—In order to obtain a representative sample of the stock to be examined, remove the bung from the cask, and with the long steel sampler remove portions from the cask in as many different directions as desired until a suitable amount is collected. If different portions of the sample removed from the cask vary considerably, it will be necessary to melt the entire sample to insure homogeneity of composition. If uniform throughout, different portions of the sample may be taken and used for all the determinations. In warm weather, incipient fusion of the sample is unnecessary. In cold weather, it need be applied only to tallow and firm grease, coconut oil and cottonseed oil being easily and quickly sampled.

**60. Determination of Moisture.**—To determine the moisture present, weigh into a weighed 2½-inch porcelain evaporating dish from 3 to 5 grams of the well-mixed sample. Heat for 1 hour in a drying oven maintained at a constant temperature of 105° C. Cool and weigh. The loss in weight

multiplied by 100 and divided by the weight of the sample taken will give the percentage of moisture. This percentage is always appreciable in animal soap stock, and in the contract purchase of large quantities, rebate is generally allowed for a moisture content in excess of an allowed percentage. Cottonseed oil ordinarily contains no moisture, and the moisture determination, if applied, will generally show an increase in weight owing to oxidation. With coconut oil, the volatile matter is frequently, if not invariably, in excess of the actual moisture content, owing to the volatility of the fatty acids of low molecular weight.

**61. Determination of Free Fatty Acids.**—Aside from the melting point and titer, the determination of free fatty acids is the most important test applied to soap stock, as it gives not only an indication of the value of the stock as a source of glycerine, but of the care exercised in its manufacture and of its origin. The percentage of free fatty acids in soap stock varies, being greater in the summer than in the winter, owing to the fact that the agents of decomposition are more active in the former season. This is shown in Table IV, which gives the analytical data resulting from a long series of tests applied to the stocks mentioned.

**TABLE IV**  
**FREE FATTY ACIDS IN SOAP STOCK**

Soap Stock	Percentage Free Fatty Acids	
	Summer	Winter
Tallow . . . . .	7.85	5.85
Bone stock . . . . .	10.68	6.64
Grease . . . . .	18.03	7.49

**62.** As about 10 per cent. of glycerine is theoretically available from these soap stocks, a free fatty acidity of 10 per cent. will indicate a loss of 1 per cent. of glycerine, calculated on the basis of the stock, or 10 per cent., calculated on the amount of glycerine theoretically available.

The method of procedure is as follows: Heat the sample sufficiently to melt it, and transfer 5 cubic centimeters to an Erlenmeyer flask having a wide mouth and a capacity of 250 cubic centimeters; weigh, and add about 50 cubic centimeters of 95-per-cent. alcohol (neutral). Insert in the mouth of the flask a cork carrying a long glass tube, to serve as an air-return flow condenser, and heat the contents of the flask on a steam bath for 5 minutes.

The free-fatty-acid determination, with alcohol as a solvent, is based on the practical insolubility of neutral glycerides in alcohol, while the free fatty acids are soluble. Remove the condenser, use phenol phthalein as indicator, and titrate with seminormal caustic soda. Calculate free fatty acids in terms of oleic acid whose molecular weight is 282. One cubic centimeter of  $\frac{n}{2}NaOH = .141$  gram of oleic acid. Assuming that  $x$  cubic centimeters of  $\frac{n}{2}NaOH$  is required for neutralization, the percentage of free fatty acids may be found according to the following formula:

$$\left. \begin{array}{l} \text{Percentage of} \\ \text{free fatty acids} \end{array} \right\} = \frac{x \text{ c. c. } \frac{n}{2}NaOH \times .141 \times 100}{\text{weight taken}}$$

By measuring a definite volume of the liquid fat, much time is saved, it being a simple matter to ascertain the average weight of 5 cubic centimeters of the soap stock usually examined.

**63. Determination of Melting Point.**—The term *melting point*, as usually employed, indicates the temperature at which the portion of fat examined becomes transparent. This temperature, however, varies under different conditions, depending chiefly on the initial temperature of the body, the time during which the temperature of the fat is raised to transparency, and the consistency, or composition, of the fat. The melting point of a fat is considered to be that temperature at which a thin disk of fat, when freed from the attraction of gravitation and left to its own molec-

ular forces, assumes a globular state. Where a great many determinations are made daily, a special melting-point apparatus is used.

**64. Melting-Point Apparatus.**—The essential parts of a melting-point apparatus are shown in Fig. 15. This device consists of a test tube *c* about  $1\frac{1}{2}$  inches in diameter and 5 inches long, which is filled first with distilled water to one-third of its height. Sufficient absolute alcohol to fill another third of the tube is then added slowly, so as to avoid mixing. The test tube is supported in a large, round-bottomed glass beaker *d*. This beaker is filled with water, to serve as a water bath, is supported from the stand *f*, and is heated by means of a Bunsen burner. The water in the beaker is kept in agitation by an air jet furnished by bulb *g*, and the glass tube is thus surrounded by water at an equable temperature. The thermometer *e* is for reading the temperature of the bath.

A disk of fat, from 1 to 1.5 centimeters in diameter, prepared by allowing

FIG. 15

a drop of molten fat to fall from the end of a glass rod on a flat piece of ice, is dropped into the test tube. Being of greater density than alcohol and lighter than water, it



remains suspended at about the line of demarcation of the two liquids. A thermometer *a* divided into tenths of a degree is suspended in the test tube, with its bulb beside the disk of fat. As the temperature slowly rises, the consistency of the fat is observed. The temperature indicated by the thermometer is read off by the aid of a magnifying glass when the disk assumes a globular shape free from turbidity. Uniformity of treatment in successive determinations is essential. A different melting point can be obtained with the same sample by failure to observe uniform conditions.

Where the determinations of melting point are numerous, several of these apparatus may be arranged in a row, thus allowing a number of determinations to be carried at once.

The percentages of moisture and of free fatty acids and the melting point, together with the simple but invaluable sense tests of odor, grain, and color, amply suffice to gauge the quality of any sample of soap stock. When suspicion is aroused by the generally inferior appearance of any sample, it is well to apply the tests for unsaponifiable matter and for the percentage of alkali absorbed. •

**65. Determination of Alkali Absorbed.**—In order to ascertain the amount of alkali absorbed, weigh 2 or 3 grams of the sample into an Erlenmeyer flask of the same size as was used in the free-fatty-acid determination. Run in from a burette an accurately measured quantity of alcoholic potash of known strength sufficient to saponify the weight taken and to leave some excess. Heat on a steam bath with an air condenser until the soap formed has completely dissolved. Neutralize the excess of caustic potash required for saponification with  $\frac{n}{2}H_2SO_4$ , using phenol phthalein as indicator.

Always run a blank determination. From the difference in the number of cubic centimeters of seminormal acid used for the blank determination and for the real determination, the amount of sodium hydrate required for saponification can be calculated.

ILLUSTRATION.—The determination of the percentage of sodium hydrate absorbed will be evident from the following calculation, in which 25 cubic centimeters of alcoholic potash is used:

One cubic centimeter of alcoholic potash equals .8256 cubic centimeter of  $\frac{n}{2}H_2SO_4$ ; 25 cubic centimeters equals 20.64 cubic centimeters of  $\frac{n}{2}H_2SO_4$ .

The amount of  $\frac{n}{2}H_2SO_4$  required to neutralize the excess of alcoholic potash is 1.37 cubic centimeters; the amount of alcoholic potash, in terms of  $\frac{n}{2}H_2SO_4$ , required for saponification is 19.27 cubic centimeters.

One cubic centimeter of  $\frac{n}{2}H_2SO_4$  equals .02 gram of sodium hydrate.

$19.27 \times .02 = .3854$  gram of sodium hydrate absorbed by fat.

$\frac{.3854 \times 100}{\text{weight taken}} = \text{per cent. of sodium hydrate absorbed.}$

By referring to Tables XIII and XIV, *Manufacture of Soap*, Part 1, it can be ascertained whether this percentage is normal or abnormal. If the percentage of sodium hydrate absorbed is below the amount usually required by stock of this character, the nature of the inert material present demands examination.

**66. Determination of Unsaponifiable Matter.**—In determining the amount of unsaponifiable matter present in the sample, evaporate the contents of the Erlenmeyer flask of the preceding determination to perfect dryness and extract the residue with naphtha on a water bath, using a return-flow air condenser. When the extraction is complete, filter the contents of flask into a weighed beaker, evaporate the solvent, and weigh the residue. This will give the percentage of unsaponifiable matter present in the stock and soluble in the menstruum used.

If lime soap is present, it may be ascertained by treating the stock with dilute sulphuric acid, whereupon a precipitate of calcium sulphate is obtained, which can be confirmed by the ammonium-oxalate test. The percentage of foreign matter, animal tissue, etc. is determined by extracting a weighed portion of the sample with naphtha, whereupon all the fat dissolves. The solution is filtered through a weighed filter that, after having been washed with naphtha to remove

all traces of fat, is again weighed. From this, the percentage of foreign matter, etc. present in the stock can be calculated.

**67. Titer Test.**—All soap stock of animal origin is bought and sold on the "titer," by which is meant the highest temperature produced by the latent heat of fusion that is liberated on the solidification of the pure liquid fatty acids obtained from the stock. This test is also called the *hardness test*.

In *Quantitative Analysis* is given the method of titer determination as proposed by Wolfbauer. To obtain reliable results by whichever modification of this method that is used, it is essential that each determination be made under precisely uniform conditions and from fatty acids prepared in the same manner. This determination may also be applied to cottonseed and coconut oils. For the former stock, it is a reliable index of the soap-making qualities of different samples of oil.

The titer test requires about 4 hours for the entire operation, but since all tallows and greases are bought on this test, and since it is by far the most important test that can be given to a stock, it should in all cases be performed where a chemist is employed.

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#### ANALYSIS OF ROSIN

**68. Determination of Unsaponifiable Matter.**—The only chemical test commonly applied to rosin is the determination of the unsaponifiable matter, which increases, as previously stated, as the quality of the rosin deteriorates. The grading accorded the barrel from which the sample is taken is determined by comparing with standard cubes a cube cut from the sample, with dimensions equal to those of the standard. Care should be taken to have the sample cube representative of the quality of rosin in the barrel. The unsaponifiable matter present is determined in the same manner as the unsaponifiable matter in glyceride stock.

**69. Comparison With Standards.**—Rosin of a given grade should correspond in color and clearness with the

standard cube of the same grade. The standards should be renewed from time to time, as they tend to bleach on exposure and to lose the cube shape through softening. In comparing samples with the standards, strict uniformity of dimensions and exposure to light must be observed.

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#### ANALYSIS OF SODA ASH

**70. Determination of Sodium Carbonate.**—In order to determine the amount of sodium carbonate present in soda ash, weigh 1 or 2 grams of the sample into a 500-cubic-centimeter flask and dissolve in water; add a few drops of phenolphthalein as indicator. Run in from a burette an accurately measured excess of seminormal sulphuric acid and boil to expel all traces of carbon dioxide. Titrate the excess of acid with seminormal caustic soda. The solutions are equal and are known in terms of the various sodium compounds. The weight of sodium carbonate corresponding to the number of cubic centimeters of seminormal sulphuric acid required to neutralize the soda ash multiplied by 100 is divided by the weight of alkali taken, and the result is the percentage of actual anhydrous sodium carbonate present in the soda ash.

**71. Determination of Total Alkali.**—To determine the total alkali present, dissolve 10 grams of the soda ash in about 150 cubic centimeters of warm distilled water and dilute to 1 liter. Remove 50 cubic centimeters of this solution to a beaker and titrate with seminormal sulphuric acid, using methyl orange as indicator. Since 1 cubic centimeter of seminormal acid is equivalent to .03082 gram of  $Na_2O$ , the percentage of  $Na_2O$  in the soda ash will be found by multiplying the number of cubic centimeters of seminormal acid required by  $.03082 \times 20 \times 100$  and dividing the result by 10 (the weight of the sample taken).

## ANALYSIS OF COMMERCIAL CAUSTIC SODA

**72. Determination of Total Alkali.**—The determination of the total amount of alkali present in commercial caustic soda is carried out exactly as explained for the determination of the total alkali of soda ash. The percentage of total alkali is expressed in terms of sodium oxide.

**73. Determination of Sodium Hydrate.**—To ascertain the amount of sodium hydrate contained in commercial caustic soda, weigh out a portion, as previously explained, in a 100-cubic-centimeter, graduated flask and precipitate the sodium carbonate with boiling *BaCl*<sub>2</sub> solution. Make up to mark, shake well, and allow the flask to stand until the precipitate of barium carbonate has subsided. Filter the supernatant liquid and titrate 10 cubic centimeters with seminormal hydrochloric acid. Seminormal sulphuric acid cannot be used, as barium sulphate is insoluble. The percentage of *Na<sub>2</sub>O* is found by multiplying the number of cubic centimeters of seminormal acid required by  $.03082 \times 10 \times 100$ , and dividing the result by the weight of entire sample taken.

**74. Determination of Sodium Chloride.**—For the sodium-chloride determination, weigh 2 or 3 grams in a 100-cubic-centimeter, graduated flask, dissolve in water, and make up to mark. Transfer 10 cubic centimeters to a porcelain dish 4 inches in diameter. Dilute the aliquot portion taken with water, neutralize with dilute nitric acid and sodium-carbonate solution, using phenol phthalein as indicator, and boil to expel carbon dioxide. When perfectly neutral, add a few drops of potassium chromate as indicator and titrate with decinormal silver-nitrate solution to the appearance of a permanent, faint, reddish coloration. Each cubic centimeter of the silver-nitrate solution contains .016868 gram of silver nitrate, which will precipitate .05806 gram of sodium chloride in accordance with the following proportion:

$$\left. \begin{array}{l} AgNO_3 : NaCl \\ 168.68 : 58.06 \end{array} \right\} = .016868 : x$$

$$x = .005806$$

Multiply the number of cubic centimeters of silver-nitrate solution used by its equivalent in sodium chloride and the result by  $10 \times 100$ , and divide the whole by the weight of material taken. The result is the percentage of sodium chloride.

The results of these determinations may be expressed as follows (using the figures of an old analysis):

	PER CENT.
Total alkali as $Na_2O$ . . . . .	69.55
Free alkali as $Na_2O$ . . . . .	61.72
Combined alkali as $Na_2O$ (by difference) . .	7.83
Sodium chloride, $NaCl$ . . . . .	9.40

To express the complete results in finished form, it is necessary to transform the free alkali as  $Na_2O$  into free alkali as  $NaOH$ , and the combined alkali as  $Na_2O$  into combined alkali as  $Na_2CO_3$ . When these changes are made, the report will be as follows:

	PER CENT.
Total alkali, $Na_2O$ . . . . .	69.55
Caustic alkali, $NaOH$ . . . . .	79.64
Carbonated alkali, $Na_2CO_3$ . . . . .	10.92
Sodium chloride, $NaCl$ . . . . .	9.40
Undetermined . . . . .	.04
Total . . . . .	100.00

To judge from this report, the commercial caustic soda analyzed is of practically 70-per-cent. quality.

**75.** Caustic potash and pearl ash are examined in the same manner. If the quantity of potash purchased warrants the work, the percentage of caustic soda, sodium carbonate, potassium chlorides, and the alkali sulphates may be determined. These compounds are present as impurities.

## ROUTINE CHEMICAL EXAMINATION OF KETTLE-ROOM PRODUCTS

### ANALYSIS OF WASTE SOAP LYE

**76. Determination of Total Alkali.**—In order to determine the total alkali present in the waste soap lye, transfer 10 cubic centimeters of waste lye into a clean, 500-cubic-centimeter flask by means of a pipette. Dilute with 150 cubic centimeters of water, add phenol phthalein as indicator, and run in from a burette sufficient seminormal sulphuric acid to discharge the pink color. Boil to expel carbon dioxide and titrate back with seminormal caustic soda.

**ILLUSTRATION.—Long Method.**—The amount of  $\frac{n}{2}H_2SO_4$  required for neutralization is 1.94 cubic centimeters; 1 cubic centimeter of  $\frac{n}{2}H_2SO_4$  equals .0198 gram of  $NaOH$ . Total alkali, estimated as  $NaOH$ , equals  $\frac{1.94 \times .0198 \times 100}{10} = .384$  gram of  $NaOH$  in 100 cubic centimeters of liquor.

**Short Method.**—

	CUBIC CENTIMETERS
Total amount of $\frac{n}{2}H_2SO_4$ used is . . . . .	5.90
Amount of $\frac{n}{2}NaOH$ used for titrating excess of $\frac{n}{2}H_2SO_4$ is	3.96
Amount of $\frac{n}{2}H_2SO_4$ absorbed . . . . .	1.94

The total alkali, estimated as  $NaOH$ , is  $1.94 \times .198 = .384$  gram of  $NaOH$  in 100 cubic centimeters of liquor.

It will be observed that these methods give the percentage of alkali by volume; the percentage by weight would be slightly less.

**77. Determination of Sodium Chloride.**—In order to determine the sodium chloride contained in the waste soap lye, transfer 5 cubic centimeters of waste lye into a 100-cubic-centimeter beaker by means of a pipette and dilute with 50 cubic centimeters of distilled water. Mix well and transfer 5 cubic centimeters of the diluted lye to a 4-inch porcelain evaporating dish. Neutralize with dilute nitric acid and titrate with decinormal silver-nitrate solution, using

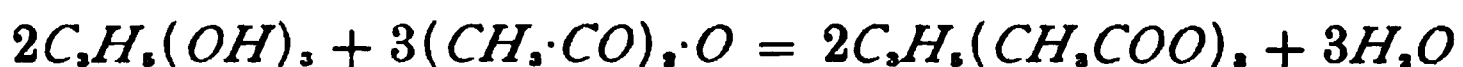
potassium chromate as indicator. Calculate the percentage of sodium chloride as if 5 grams of lye had been taken for analysis.

ILLUSTRATION.—Amount of waste lye taken is 5 cubic centimeters; amount of  $\frac{N}{10}$   $AgNO_3$  required is 20.5 cubic centimeters.

$$\frac{20.5 \times .005868 \times 100}{5} = 2.6 \text{ per cent. of } NaCl \text{ (by volume)}$$

The true percentage by weight is found by dividing the preceding result by the specific gravity of the waste lye.

**78. Determination of Glycerine.**—As the glycerine determination requires some time, it is only done when special information as to the glycerine content of a particular lye is desired. The analytical methods used industrially are based on the complete oxidation of glycerol to carbon dioxide and water. Potassium permanganate in either acid or alkaline solution may be used, according to two methods, as the oxidizing agent. In another method, potassium bichromate and sulphuric acid are used to effect the oxidation. In another, the *acetin process*, the quantitative determination of the glycerol is based on its transformation into glyceryl triacetin, in accordance with the following equation:



This method, when carried out by a chemist who is skilled in its operation, gives the most accurate results. One great source of error in all the oxidation methods for the determination of glycerol is the danger of oxidizing organic impurities that are incompletely removed from the solution. As a result, all oxidation methods give uniformly high results. In the acetin method, only the glyceride is susceptible to the action of the acetic anhydride. The method, however, is time-consuming and is not satisfactory for industrial laboratories. Nevertheless, it is a good plan to become familiar with this method, as its chief value lies in its being used as a check on the more easily and quickly manipulated oxidation methods. Again, the acetin method is not applicable to waste soap lye, because of the danger of



hydrolysis of the unstable glyceryl triacetin in the presence of a large excess of water. It is used almost exclusively on crude glycerines.

**79. Acetin Method.**—When the acetin method is employed, about  $1\frac{1}{2}$  grams of crude glycerine is heated with 7 or 8 grams of acetic anhydride and 3 grams of anhydrous sodium acetate. The function of the last reagent is to absorb water. The mixture is gently boiled for  $1\frac{1}{2}$  hours in a flask provided with a water-cooled, return-flow condenser. At the expiration of this period, cool the contents of the flask and introduce 50 cubic centimeters of water through the condenser. With the condenser attached, agitate with slight warming until the oily matter in the bottom of the flask has dissolved. Filter when cool, and to the filtrate add a few drops of phenol phthalein. Run in dilute caustic soda (20 : 1,000) from a burette until just neutral (until the yellow color just changes to reddish yellow). Now run in from a burette a measured quantity of 1 : 10 caustic-soda solution of known strength (about twice normal or a little stronger). Heat the contents of flask on a water bath and titrate the excess of caustic soda with normal hydrochloric acid. The percentage of glycerol present, as calculated from the amount of sodium hydrate used to saponify the triacetin, will be evident from the following calculation:

**ILLUSTRATION.**—The amount of (1 : 10) sodium-hydrate solution added after neutralization was 27.15 cubic centimeters. One cubic centimeter of (1 : 10) sodium-hydrate solution equals 2.42 cubic centimeters of normal hydrochloric acid. Therefore, 27.15 cubic centimeters  $\times$  2.42 = 65.70 cubic centimeters, the equivalent of 27.15 cubic centimeters of (1 : 10) sodium hydrate in normal hydrochloric acid.

After saponification, 33.2 cubic centimeters of normal hydrochloric acid was required to neutralize the excess of (1 : 10) sodium hydrate; 65.7 cubic centimeters less 33.2 cubic centimeters equals 32.5 cubic centimeters of normal hydrochloric acid, which is equivalent to the sodium hydrate required for the saponification of the triacetin. One cubic centimeter of normal acid equals .03066 gram of glycerol; 32.5 cubic centimeters of normal acid equals .99645 gram of glycerol; weight taken for analysis equals 1.2501 grams.

$$\frac{.99645 \times 100}{1.2501} = 79.71 \text{ per cent. glycerol present}$$

**80. Bichromate Oxidation Method.**—In the bichromate oxidation method, 1 part of glycerol is completely oxidized to carbon dioxide by 7.486 parts of potassium bichromate in the presence of sulphuric acid. In carrying out this method, the following solutions will be necessary:

*Standard Potassium Bichromate.*—Dissolve 74.86 grams of pure potassium bichromate in distilled water, add 150 cubic centimeters of concentrated sulphuric acid, and when cold make up to 1 liter. This solution is of such a strength that 1 cubic centimeter equals .01 gram of glycerol. (For some purposes it is well to have a solution of one-tenth this strength, which is obtained by making 100 cubic centimeters of the strong solution up to 1 liter.)

*Ferrous Ammonium-Sulphate Solution.*—Dissolve 240 grams of pure ferrous ammonium sulphate in 50 cubic centimeters of concentrated sulphuric acid and sufficient water, and when cold dilute to 1 liter. The strength of this solution should from time to time be accurately determined against the bichromate solution. Potassium ferricyanide is used as indicator on a spot plate.

*Method.*—Weigh out 1.5 grams of the soap lye into a 25-cubic-centimeter graduated flask. For the removal of chlorine and aldehydic compounds, 1.5 grams of silver oxide is added. This should be a sufficient excess. The silver oxide is acidulated with sulphuric acid. The mixture must be of uniform consistency—about that of mush. Make up to the 25-cubic-centimeter mark with distilled water and then carefully add an excess of water corresponding to the volume of the silver oxide in a dry state. Thoroughly agitate the contents of the flask until all turbidity remaining after a few seconds has disappeared. If the solution remains colored after turbidness has ceased, it is due to imperfectly removed organic matter. Unless the waste lye is extremely foul, agitation with silver oxide usually suffices for complete purification. With very foul samples, basic-lead-acetate solution may be used for purification. This is added before making up to mark.

Filter through a dry filter, and digest 5 cubic centimeters of this filtrate for 2 hours in boiling water with from 8 to 10 cubic centimeters of the strong standard bichromate solution (accurately measured) and 15 cubic centimeters of strong sulphuric acid, in a clean covered beaker.

Titrate the excess of bichromate with the ferrous ammonium-sulphate solution. Care should be taken in titrating that the standard solutions are at the normal temperature, as, being strong, a slight change in temperature makes an appreciable difference.

Subtract the excess of bichromate found from the total volume taken; the difference is the amount consumed in the oxidation of the glycerol in one-fifth of the sample. This difference in cubic centimeters multiplied by  $5 \times .01 \times 100$ , and the product divided by 1.5 (the weight of the sample taken) will give the percentage of glycerol in the waste lye.

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## SOAP ANALYSIS AND THE INTERPRETATION OF RESULTS

81. In *Quantitative Analysis* is given an exposition of the essential principles of soap analysis. As further discussion of analytical methods is unnecessary at this point, attention will be confined to the interpretation of the results obtained by the chemist. The analysis reported is as follows:

	PER CENT.
Water . . . . .	19.26
Alkali combined as soap, $Na_2O$ . . . . .	8.57
Alkali free as $NaOH$ . . . . .	.20
Alkali as $Na_2CO_3$ . . . . .	.20
Fatty anhydrides . . . . .	52.32
Rosin . . . . .	19.45
Total . . . . .	<u>100.00</u>

These data will be arranged in a different manner, so that the manager of the works can see at a glance the informa-

tion that he desires. The analysis reported is modified as follows:

	PER CENT.
Water . . . . .	19.26
Soap (anhydrous) { Combined alkali, $Na_2O$ . . . . . 8.57	80.34
{ Fatty anhydrides . . . . . 52.32	
{ Rosin . . . . . 19.45	
Free alkali, $NaOH$ . . . . .	.20
Carbonated alkali, $Na_2CO_3$ . . . . .	.20
Total . . . . .	100.00

82. It will be assumed that the sample analyzed is a fairly fresh piece of soap, not having undergone much drying. Settled rosin soap fresh from the cutting table is known to contain from 30 to 35 per cent. of water. The exceptionally small percentages of free and carbonated alkali, as well as the complete absence of even traces of unsaponifiable matter, indicate a completeness of saponification seldom arrived at in practical work. It is possible to tell from the appearance of the sample whether the soap is a cold-process or settled soap. The absence of glycerine and the practical absence of free alkali and unsaponified matter confirm the decision as to its being a settled soap. But the soap contains a very small percentage of water. It is not the ordinary settled soap so well known in the United States. If it were even a straight semiboiled soap, it would contain some glycerine. It is thus decided that the sample under examination is a settled soap that has either been grained strongly after the strengthening change—which, as can be told from the completeness of saponification, has been thorough—or has been subjected to a partial boiling down on closed steam, whereby, by either procedure, 10 per cent. of water has been eliminated. This soap does not contain a particle of filling of any description, from which it may be inferred that the liquid soap may have been pumped directly from the kettle to the frame without crutching. If the soap has a broad, open texture resulting from the slow crystallization of the sodium stearate in a menstruum of sodium

oleate and sodium resinate, it is safe to say that the soap has not been crutched. If the soap is homogeneous in texture, with no marked crystallization, it has been crutched, in which process the texture arising from the slow cooling of the unfilled soap in the frames is broken up by the intimate mixing in the crutcher of the soap formed from fatty acids of different melting points.

**83.** The chemist's report shows the presence of 19.45 per cent. of rosin and 52.32 per cent. of fatty anhydrides. From these figures the proportions of the glyceride stock and rosin that have been killed in the kettle can be readily determined. For purposes of calculation, the presence of 52.32 per cent. of stearic anhydride will be assumed. Ninety-seven parts of stearic anhydride will yield by the absorption of the elements of water 100 parts of stearic acid; 90 parts of stearic acid is equivalent to 100 parts of stearin. These equivalents become clear on working out the following proportions:

Molecular weight of stearic anhydride . . . . .	550
Molecular weight of stearic acid . . . . .	284
Molecular weight of stearin . . . . .	890
Molecular weight of $3H_2O$ . . . . .	54
Molecular weight of glycerine . . . . .	92

$$890 : 92 = 100 : x$$

$x = 10.337$  per cent. of glycerine yielded on saponification.

$$890 : (3 \times 284) = 100 : x$$

$x = 95.72$  per cent. of fatty acid yielded on saponification.

$$890 : 54 = 100 : x$$

$x = 6.07$  per cent. of water absorbed on saponification.

	PARTS
Stearin . . . . .	100.00
Glycerine formed therefrom on saponification	10.34
Fatty anhydrides yielded (approximately 90)	89.66

$$(2 \times 284) : 550 = 100 : x$$

$x = 97$  (approximately) parts of stearic anhydride yielded by 100 parts of stearin.

52.32 per cent. of stearic anhydride  $\div .97 = 53.94$  per cent. of stearic acid.

53.94 per cent. of stearic acid  $\div .9 = 59.94$  per cent. of stearin.

For every 59.94 parts of glyceride stock, 19.45 parts of rosin has been used.

$$19.45 \div .5994 = 32.45 \text{ per cent. rosin}$$

Approximately 33½ pounds of rosin has been used for every 100 pounds of glyceride stock. This is an exceptionally good soap for all laundry purposes.

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### CHEMICAL EXAMINATION OF REFINED GLYCERINE

**84. Determination of Salt.**—To determine the amount of salt contained in a sample of glycerine, 50 grams of the sample is weighed on the coarse balance into a bowl-shaped nickel crucible and heated carefully to the point of ignition. Combustion of the glycerine is allowed to proceed until the flame goes out of its own accord. The carbonaceous matter remaining is carefully ignited, so as not to lose any sodium chloride by volatilization or decrepitation. Dissolve the ignited mass in warm water and transfer the solution to a small porcelain evaporating dish. Titrate with decinormal silver-nitrate solution and calculate the results.

**85. Determination of Carbonaceous Matter.**—To determine the amount of carbonaceous matter present in the sample, weigh 5 grams accurately into a small porcelain crucible. Heat the crucible carefully to the point of ignition of the glycerine and allow combustion to proceed. When complete, gently flash the flame of a Bunsen burner below the crucible to burn traces of glycerine remaining. Do not heat enough to oxidize the carbonaceous matter. Cool and weigh. The weight of the residue multiplied by 100 and divided by the weight of the sample taken will give the percentage of carbonaceous matter.

**86. Determination of Ash.**—To determine the ash present, weigh out 25 grams of glycerine on the coarse balance into a weighed platinum dish. Heat carefully to ignition and allow combustion to proceed. Expel all carbonaceous matter with a strong Bunsen-burner flame, taking care to lose no salt by volatilization or decrepitation. Cool and weigh on the fine balance. Calculate the percentage of ash as in the preceding case.

**87. Total Acid Equivalent.**—The total acid equivalent may be found by weighing out 100 grams of glycerine, transferring it to a beaker, and making it up to 300 cubic centimeters with distilled water. A few drops of a 1-per-cent. solution of alcoholic phenol phthalein are added, and then 20 cubic centimeters of  $\frac{n}{4}$  sodium-hydroxide solution. Boil for 5 minutes and then run in  $\frac{n}{4}$  sulphuric acid until the pink color is discharged. The result is expressed in grams of sodium hydroxide, and should not exceed .15 per cent.

**88. Higher Fatty Acids.**—Pass a stream of nitrogen tetroxide through a portion of the glycerine that is diluted with twice its volume of distilled water and contained in a test tube. After this operation place the test tube on a steam bath and heat for 2 hours. Glycerine that is to be used for the manufacture of nitroglycerine should give no precipitate, either on dilution or later in the operation. Glycerine that will stand this test may be considered free from higher fatty acids.

**89. Neutrality.**—A glycerine may be considered neutral if, when 50 grams is diluted with twice its weight of distilled water and a few drops of an alcoholic solution of phenol phthalein are added, not more than 1 cubic centimeter of  $\frac{n}{4}$  sulphuric-acid or sodium-hydroxide solution is required to produce a change in color.

**90. Specific Gravity.**—For the specific-gravity determination, a Westphal balance is used. After balancing the apparatus accurately, either in distilled water at 15° C. or, preferably, in the air, the determination is made at the temperature of the room. The reading is taken directly from the weights used and is accurate to the fourth decimal place. If the temperature of the room is not at 15° C., a correction must be made. The correction is equivalent to .00056 gram for each degree centigrade. This is added to the result already obtained if the temperature is above 15° C., but is subtracted from the same if the temperature is below 15° C.

**91. Permanent Specific Gravity.**—Heat a sufficient amount of glycerine for a specific-gravity determination in a 300-cubic-centimeter flask for 2 hours at a temperature between 225° C. and 230° C. Place the glycerine in a desiccator and allow it to come to the temperature of the room. The specific gravity is then determined as before. The result is corrected to 15° C. and is the permanent specific gravity.

**92. Ætna Standard for Refined Glycerine.**—The following specifications are accepted as the standard, not only by the producers, but also by most consumers of dynamite glycerine:

	PER CENT.
Specific gravity at 15° C. . . . .	1.2620
Sodium chloride . . . . .	.008
Ash . . . . .	.010
Reaction . . . . .	Must be neutral
Higher fatty acids . . . . .	None
Lower fatty acids . . . . .	.600





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